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ABSTRACT

This comprehensive document is the result of statewide planning for the implementation of metric education in Virginia schools. An introduction discusses the rationale, needs, and continuing objectives for metric education. An organizational structure for metric education in Virginia is outlined. Guidelines for administrative planning are presented in terms of organizing local metric programs, community awareness programs, educational media, inservice programs, school lunch program, telecommunications, teacher certification, and the state testing program. Instructional programs are outlined in some detail for: elementary, adult, agricultural, art, business, distributive, driver, English, foreign language, health and physical, home economics, industrial arts, mathematics, music, science, social studies, special, trade and industrial, and vocational education. Curriculum applications, teacher education, and activities for students are presented for each subject matter field. An annotated bibliography, sources of free materials, metric measurement activities and games, guidelines for evaluation, a teacher's self-inventory, an attitude scale, criteria for selecting materials, and sample test items are also included. (MS)

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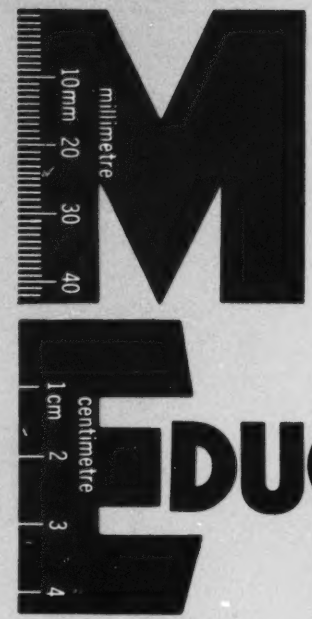

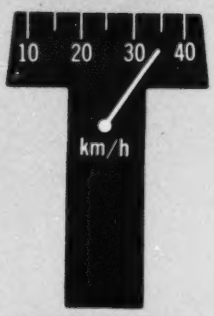

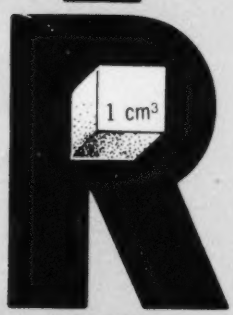

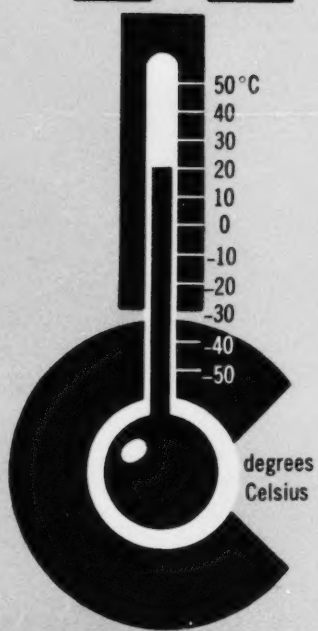

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METRIC EDUCATION PLAN FOR VIRGINIA

DEPARTMENT OF EDUCATION
COMMONWEALTH OF VIRGINIA
RICHMOND, VIRGINIA 23216

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METRIC EDUCATION PLAN FOR VIRGINIA

Prepared by: Division of Secondary Education
Department of Education
Commonwealth of Virginia
Richmond, Va. 23216
June 1977

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FOREWORD

The inclusion of the International System of Units (SI) into American society demands the attention of educational planners. It is paramount that all boys and girls as well as adults in the Commonwealth of Virginia be given proper instruction in the use of SI metric units. In order for metric education to be relevant, effective, and efficient, however, activities must be planned and coordinated inside and outside the education community.

The Mathematics Service of the Division of Secondary Education, being aware of the importance of metric conversion, has given leadership in developing this metric education plan for Virginia. The plan addresses all instructional areas and all levels of education across the state. The project was funded by a grant from the United States Office of Education.

Development of the plan involved numerous individuals. A Steering Committee with statewide membership gave overall focus to the project. In addition, a metric planning committee, composed of members representing various disciplines in school divisions and the State Department of Education, was given the task of developing recommendations for their areas of specialization, recommending guidelines for an interdisciplinary approach to metric education, and reacting to the overall plan. The results of the work done by the committees comprise the bulk of this publication.

Keeping metric education efforts in step with the conversion process of other sectors of society and coordinating efforts within the education community itself are important factors for success in the metric conversion program. With these ideas in mind it is our hope that this publication will assist in a smooth transition to metric usage in the schools and in the communities.

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The Department also expresses its appreciation to the vast number of individuals who were instrumental in the development of this plan. Their contributions and suggestions greatly enhanced the finished product, hopefully making it a more useful document.

TABLE OF CONTENTS

	Page
Foreword	iii
Acknowledgements	iv
Introduction	vii
Organizational Structure for Metric Education	1
Guidelines for Administrative Planning	3
Organizing Local Metric Programs	3
Community Awareness Program	3
Educational Media	4
Inservice Programs	5
School Lunch Program	7
Telecommunications	8
Teacher Certification	8
State Testing Program	8
Instructional Programs	9
Elementary Education	9
Adult Education	11
Agricultural Education	12
Art Education	14
Business Education	15
Distributive Education	16
Driver Education	17
English Education	18
Foreign Language Education	20
Health and Physical Education	21
Home Economics Education	22
Industrial Arts Education	23
Mathematics Education	24
Music Education	26
Science Education	27
Social Studies Education	28
Special Education	29
Trade and Industrial Education	30
Vocational Education	31
Annotated Bibliography	33
Appendices	37
Appendix A	37
Appendix B	38
Appendix C	43
Appendix D	46
Appendix E	49
Appendix F	51
Appendix G	52
Appendix H	53

INTRODUCTION

Rationale

The plan for statewide implementation of metric education contained herein is consistent with the goals for public education in Virginia adopted by the Board of Education in 1975. As set forth in those goals public education seeks to aid each pupil, consistent with his or her abilities and educational needs, to

(1) Become competent in the fundamental academic skills
(2) Be qualified for further education and/or employment
(3) Participate in society as a responsible citizen
(4) Develop ethical standards of behavior and a positive and realistic self-image
(5) Exhibit a responsibility for the enhancement of beauty in daily life, and
(6) Practice sound habits of personal health

The relationship of all these goals to competence in the use of measurement is clear. More specifically, the attainment of these goals is, in a real way, dependent upon the development of competence in the *metric* system of measurement. Measurement permeates almost every aspect of daily life; a change to the metric system of measurement in the United States is inevitable, imminent, and in fact already in progress or completed in some sectors of industry.

The International System of Measurement Units (SI), which is being used in more than 90 percent of the world, will replace most units of measurement in the next few years. Public Law 93-380, Section 403, which was enacted by Congress on August 21, 1974, states in part:

(1) The Congress finds that
   a. The metric system of measurement is in general use in industrially developed nations and its use is increasing
   b. Increased use of such metric system in the United States is inevitable, and such a metric system will become the dominant system of weights and measures in the United States; and
   c. There is no existing federal program designed to teach children to use such a metric system and such a program is necessary if the American people are to adapt to the use of the metric system of weights and measures.

(2) It is the policy of the United States to encourage educational agencies and institutions to prepare students to use the metric system of measurement with ease and facility as a part of the regular educational programs.

More significantly in the fall of 1975, the Congress passed and the President signed Public Law 94-168 known as the Metric Conversion Act of 1975. This act declares it to be national policy to plan and coordinate the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the conversion to the metric system.

Voluntary conversion to the metric system already is occurring because of its obvious advantages to society. It is a coherent decimal system requiring no complicated conversion factors, and its use will facilitate communication and trade with virtually all the nations of the world.

The United States is the last of the English-speaking nations and, indeed, the last industrial nation to go metric. As a result, the educational system has been able to profit from the experiences of other nations which converted to the metric system. Since the primary responsibility for teaching measurement has been and is that of the schools, it is incumbent upon the educational establishment to begin now to prepare its clientele—both students and community—for the use of the metric system.

Needs

Limited efforts, primarily in mathematics and science classes, have been made to provide students with the knowledge and skills necessary to use the metric system of measurement effectively in daily life. Past educational activity in Virginia dealing with conversion to the metric system generally has been fragmented. Little or no effort has been made to coordinate and develop metric activities in the various curriculum and support service areas.

The conclusion drawn from an analysis of current information on metric education in Virginia is that statewide efforts must be initiated essentially from "ground zero". While this approach has its disadvantages, it also affords an opportunity for a fresh and systematic development of continuing objectives for metric education in the state.

Continuing Objectives

The success of a movement toward metric education calls for the systematic development of realistic objectives designed to meet assessed needs. Certain competencies or skills are needed

by all people if they are to function effectively as consumers and wage earners.

Competencies related to measurement can be classified in the following categories:

(1) Communication competencies
   a. Know the base units and the commonly used prefixes (milli-, centi-, kilo-)
   b. Know the symbols of the various units and multiples (centimetre-cm, kilogram-kg)
   c. Use appropriate SI symbols for recording measurements
   d. Read a measurement scale
      1. Determine precision (smallest unit which can be directly read on the scale)
      2. Read and record measurement in metric units (degrees Celsius for daily temperature)
   e. Use equivalency charts and tables for converting within the metric system
   f. Interpret metric sizes (1200 cm^3 is the displacement of a small auto engine, 4.2 litres is the displacement of a mid-size American engine, two metres is the height of a tall basketball player)

(2) Measurement competencies
   a. Use correct measurement techniques (check for zero adjustment when using kilogram spring scale, when using measuring tape check for straightness of tape and correct positioning of zero)
   b. Identify appropriate SI unit for making or recording a measurement
   c. Estimate and measure distances using millimetres, centimetres, metres, or kilometres, as appropriate
   d. Estimate and measure volumes using litres and millilitres
   e. Determine the mass of objects using kilograms or grams (zero adjustment and correction for weight of container as needed)
   f. Determine the area of a region using appropriate units and measurements
   g. Select and use tools in metric sizes (metric measures in cooking utensils, metric wrenches, drills)

(3) Problem-solving competencies
   a. Solve problems involving metric units of length to compute areas and volumes
   b. Use ratios
      1. To solve problems involving metric units and unit pricing (cents/kilogram, cents/litre, as well as kilogram/cent)
      2. To solve problems involving other averages (kilometres/hour, kilometres/litre of gasoline)
      3. To solve problems involving power (work/time) and pressure (force/area)
   c. Use decimal system of numeration fluently or use the calculator to change metric units

(4) Consumer competencies
   a. Be able to identify metric sizes (shoes, clothes)
   b. Determine appropriate metric units for buying or selling goods (milk or gasoline in litres, water in cubic metres, meat in kilograms)
   c. Know the legal speeds for driving an automobile (88 km/hr. on highway, 24 km/hr. in school zone) and interpret distances between cities (in kilometres)
   d. Think in metric units (square metres of carpet, litres of paint, cubic metres of concrete)

Conversion to the metric system of measurement will be gradual. Since various sectors of business will be converting to the system at different times educational needs of the public will vary. To assure the success of metric education, school officials must continually evaluate their efforts to be certain that measurement objectives are meeting current needs.

ORGANIZATIONAL STRUCTURE FOR METRIC EDUCATION

The organizational structure for metric education in Virginia is designed to utilize individuals with various backgrounds who have a common interest in metric conversion and its effect on the community.

Organization

(1) A Metric Education Council will be established. This council will be comprised of a local representative from each of the seven regions in the state.

(2) A Metric Coordinating Committee will be formed. This committee will be comprised of one representative from each service and/ or division in the State Department of Education and will work with the Metric Education Council.

(3) Each locality will appoint a coordinator of metric education.

The organizational structure described above is shown in Figure 1.

Activities and Functions

Activities relating to metric conversion should utilize existing state and local programs and structural organization as much as possible. In so doing, the cost of converting to the metric system will be kept to a minimum both in dollars and in manpower. The following activities, functions, and services are suggested.

(1) The Mathematics Service of the State Department of Education will provide the leadership in planning and implementing metric education.

(2) The Metric Education Council will keep the Metric Coordinating Committee informed on changes in measurement as they relate to specific sectors of the community and make recommendations on educational needs.

(3) Each service and/or division will work with people in that area of specialization on the local level to implement the metric education program.

(4) Those services and/or divisions with adult education components will design a program for metric awareness for use in their services.

(5) The Adult Education Service will encourage the development and offering of courses in metric measurement on the local level.

(6) The Mathematics Service will

*a. Conduct a series of 23 workshops on measurement for teachers and supervisors of mathematics

b. Conduct a series of leadership training institutes on organizing and initiating in-service training programs on metric measurement. The workshops will be for individuals responsible for inservice education in local school divisions

c. Conduct a series of workshops to train individuals to conduct metric workshops on the local level

d. Establish a metric information center with a reservoir of appropriate materials about the metric system

e. Develop a list of persons who are qualified and are available to conduct workshops and speak on the metric system

(7) All other services and/or divisions of the State Department of Education will develop a list of resource groups, organizations, and agencies, and a list of reference materials. The lists will be related to the particular area of specialization. Preparation of the lists will be coordinated through the Metric Coordination Committee.

*Objective completed.

ORGANIZATIONAL STRUCTURE

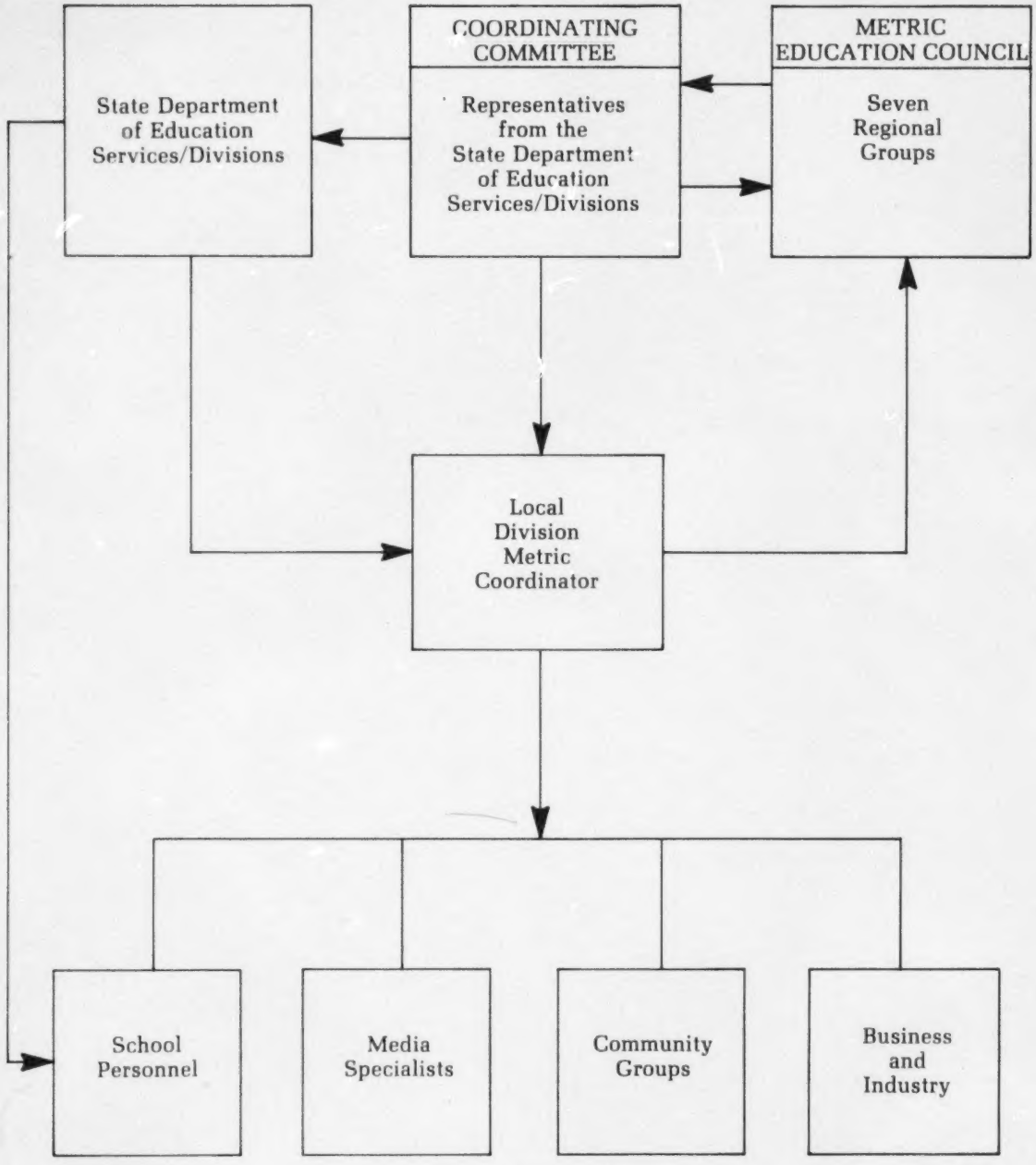


Figure 1

GUIDELINES FOR ADMINISTRATIVE PLANNING

ORGANIZING LOCAL METRIC PROGRAMS

Select a Metric Coordinator

(1) One person must be assigned the responsibility for metric education in each locality so that the program will be conducted effectively and economically. Hence it is suggested that each local school division select a metric coordinator.

(2) The qualifications for a metric coordinator are similar to those of a curriculum specialist or director of instruction. The person selected should be familiar with the metric system (SI) or be willing to learn it as quickly as possible and be motivated to help promote the program.

Identify Target Groups

(1) Outline a plan for metrication including target groups and estimated times, a schedule of workshops and training sessions (which must be entered into the school calendar). Select key teachers and principals to train first, decide on needed equipment to have it available for training sessions. Plan to select a metric coordinator for each school.

(2) The plan should include an awareness phase, an introductory phase, and an implementation phase from which students and parents will become competent in using metric units.

Provide Necessary Equipment

(1) Learning to measure requires experience in the act of measurement. Filmstrips or workbooks cannot replace the experience of actually measuring objects in the school environment. It is recommended that initial purchases of equipment include measuring tapes, scales, Celsius thermometers, and plastic centimetre cubes. Filmstrips and booklets should not be selected until a committee of teachers reviews the material as part of the metric training. We strongly recommend that school personnel shop for quality materials at a reasonable price. Refer to Appendix G for more information on selecting materials.

Metric Awareness in the Community

(1) Through workshops and inservice training teachers should learn basic metric concepts and the reasons why the United States has adopted the metric system.

(2) Parents should be informed through P-TA presentations that the children are learning metric units. Efforts should be made to provide metric instruction for those adults who desire it.

(3) Community leaders should be informed of metrication plans. Emphasis should be placed on the fact that metrication is not compulsory, that there will be reasonable time for the changeover from the customary measurement system and that careful planning will reduce costs.

(4) Local newspapers and radio stations should be kept informed of metric training sessions and other pertinent information relative to metric education.

COMMUNITY AWARENESS PROGRAM

Educators should attempt to stimulate interest in the metric system and encourage community leaders to accept responsibilities in community programs. Adults as well as students will use the metric system as it becomes a part of American life. Programs should be planned carefully and implemented to involve as many segments of the community as possible.

Below is a list of community groups and organizations, educational agencies, and governmental agencies which may be utilized to develop awareness programs that reflect local metric education needs. The list is not intended to be all inclusive; it is hoped that program coordinators (planners) will explore other sources of support and assistance.

(1) Community groups and organizations, educational agencies, and governmental agencies

Armed services and research groups
Agriculture and commerce organizations
Chambers of commerce

Civic organizations
Conservation and environmental groups
Consumer advisors and county agents
Education associations
Health services organizations
Faculties of institutions of higher education
Local and state education advisory committees
Legislative advisory committees
Marketing organizations
Media organizations
Police departments
Retailing associations
Social service organizations
Vocational and trade organizations

(2) Listed below are suggestions for involving the public and obtaining local support for metric education programs.

a. Conduct metric awareness programs for representatives of local organizations. These organizations may designate "metric representatives" and have them participate in a workshop

b. Identify key persons who have participated in awareness training and involve them in promoting metric usage

c. Obtain support from local merchants associations and representatives of business and industry to develop and distribute "awareness-type" materials

d. Prepare printed materials for students to take home to parents

e. Arrange appearances on TV and radio talk shows to answer questions on metrication

f. Conduct workshops for school boards and local government officials

g. Publicize metric TV programs that are being broadcast for school and public viewing

h. Develop awareness-type materials such as pamphlets, brochures, and bookmarks, and make them available at state and local fairs and through community groups and other appropriate means

(3) Listed below are suggestions for funding local programs.

a. Have a speaker appear before the General Assembly perhaps as a representative of local advisory committees to seek allocation of funds for the program

b. Become aware of funding available for metric education programs

c. Identify monies available for education through organizations, city councils and local agencies

EDUCATIONAL MEDIA

It is generally agreed that the change to the metric system of measurement will have an impact on our school curricula. Additionally, it is apparent that what we are talking about is not merely a mechanical conversion from customary to metric units in the existing curricula but substantive changes requiring appropriate reference materials and information.

The library, being the primary source of reference materials for students and teachers, must have accurate and current metric information available. The question then becomes what is an efficacious course of action? What follows is a list of recommendations and suggestions for such a course.

(1) Since many reference books will not be replaced for a number of years, librarians and teachers should make an effort to adapt, where possible, tables and other information given in the English or customary system of measurement to the metric system.

(2) It is not necessary to set aside large amounts of special funds for purchase of metric materials; however it is suggested that over the next several years metric materials should be given priority.

(3) With the assistance of teachers and supervisors, determine the areas of greatest need in reference materials and textbooks.

(4) In the purchasing of new materials care should be given to select materials that contain correct SI usage. (There is more than one metric system of measurement. The U. S. along with other countries is adopting the International System of Units (SI).) Avoid those which teach conversion from the customary system to the metric system since this can be accomplished through use of equivalency charts.

(5) In the purchasing of new materials guard against distributors attempting to reduce their inventories of outdated or inaccurate materials. Pay particular attention to special mail offers and sales.

(6) Purchase and have available several copies of metric system reference tables for teachers' and students' use.

(7) Examine almanacs, yearbooks, handbooks, and manuals to determine where it might be desirable to insert tables of metric measurements.

(8) Secure—if available—from publishers of encyclopedias and other major references, inserts giving metric notation and scales.

(9) Obtain books on the history of and use of the metric system.

(10) Indicate metric materials by marking the spines of books and through special displays.

(11) Some media items such as globes and film materials may be difficult to adapt; therefore, equivalency charts should be readily available until these items can be replaced.

(12) Secure lists of recommended metric-related materials from the State Department of Education or other reliable sources. These lists should be available for teachers' use also.

INSERVICE PROGRAMS

The effectiveness of a school's services and the success of its programs depend upon the efforts and participation of all personnel. Therefore, it is necessary that administrators, supervisors and all staff members be involved in the metric education programs.

Because teachers have the primary responsibility for instruction they must be aware of metric measurement and also be prepared to use it in their classrooms.

It is recommended that by July 1, 1979, educational personnel in the Virginia public schools will have participated in a metric measurement inservice program ranging from 3 hours to 16 hours.

Hours for inservice instruction should be planned according to job classification. The chart below should serve as a guide in determining involvement.

SUGGESTED NUMBER OF HOURS OF INSERVICE

3-7 HOURS	8-12 HOURS	13-16 HOURS
	Elementary	Elementary-Mathematics*
		Mathematics
		Vocational
	Science	
	Liberal Arts	
	Supervisory	
	Administrative	
Supportive**		

*Teachers of the intermediate grades should participate in a minimum of 16 hours of in-service.

**Supportive personnel includes the clerical, cafeteria, and maintenance staffs.

Goals for Inservice Programs

The participant will

(1) Become aware of the simplicity of the metric system

(2) Realize that some measures in the metric system are already in use

(3) Review the basic assumptions concerning measurement and the concepts of accuracy and precision in measurement

(4) Review the International System of Units and the relationship to the decimal numeration system

(5) Become aware of various specialized applications of measurement using the metric system

(6) Review the "do's" and "don'ts" for teaching SI units

(7) Develop awareness of various types of consumer applications

(8) Determine metric measurement concepts which may be taught to students at various grade levels

(9) Have experiences with measurement using the metric system

(10) Develop the ability to read instruments which are metrically scaled

(11) Become aware of those components of the metric system which are commonly used

Inservice Programs for Elementary Teachers*

The following components should be incorporated in metric awareness programs.

(1) History—A brief historical background on measurement should be presented that includes progress made in the implementation of SI metric at the national and international levels

(2) Advantages of the SI metric system—Teachers should be made aware of the advantages

of SI metrics and the relationship to the decimal numeration system

(3) Resistance to changing to SI metrics—Teachers should expect some natural resistance to the acceptance of the SI metric system and should be prepared to cope with resistance in a positive manner

(4) Introduction to SI metric units—Teachers should be introduced to SI metric units with emphasis on those which are commonly used

Experiences with metric measurement should be based on real situations. The following topics are recommended.

(1) Activities similar to those in which students will be involved. The activities should range from free exploration with a variety of materials to such structured exercises as:
   a. Measurement activities directly related to real world situations
   b. Construction and use of simple measurement devices
   c. Games, puzzles, and problems to develop and reinforce the basic concepts and skills of measurement and to achieve proficiency in conversion techniques within the metric system

(2) Diagnostic techniques that enable the teacher to determine the level of conceptual and skill readiness of students

(3) Experiences that enable teachers to acquire a knowledge of the prefixes, symbols, and notation terminology used in SI metrics

(4) Experiences that enable teachers to use a variety of community resources (see community awareness section for more information)

Inservice Program for Secondary Teachers*

The following components should be incorporated into metric awareness programs.

For all teachers in grades seven through twelve

Historical background
Legal status
Implications of metric implementation (national economy, education, and consumer)
Units of length, mass/weight, time, temperature, volume/capacity, and speed
Decimal system of numeration
Metric prefixes and symbols
Issues and concerns

*This section is a modified version of the recommendations in the *Final Report of the Interstate Consortium on Metric Education* (Sacramento, California: State Department of Education, 1975) pp. 13-16.

For vocational/technical teachers

Essential metric units, prefixes, and symbols
Industrial uses
Mass-weight clarification
Other skills needed for specific subjects
Funding opportunities

For mathematics and science teachers

Technical definitions of base units
Derived and supplemental units
Scientific notation

Experiences with metric measurement should be based on real situations. The following topics are recommended:

For all teachers in grades seven through twelve

Personal measurements
Estimations and verifications
Error in measurement and approximation
Selection of appropriate units
Construction and calibration of measuring instruments
Practice with measuring
Conversion within the metric system
Unit pricing practices
Criteria for selection of instructional materials

For vocational/technical teachers

Vernier scales
Metric (radial) protractors
Map and scale drawings
Mensuration formulas
Instruments used in specific courses
Conversion skills needed for specific courses

For mathematics and science teachers

Small and large units of measurement
Application of time units
Factor label/unit analysis
Map and scale drawing skills
Mensuration formulas
Instruments used in specific courses

For mathematics and science teachers at the senior high school level only

Derived units as needed
General physical constants
Derivation of physical formulas
Sophisticated instruments
Conversion skills needed for specific courses

General Recommendations for Inservice

(1) Individuals planning inservice should refer to the following

"Inservice Guide to Teaching Metric Measurement", available from the Division of

Secondary Education, Department of Education, Commonwealth of Virginia

"Final Report of the Interstate Consortium on Metric Education", available from the California State Department of Education

(2) Plans for inservice training should be coordinated with local school division policies for awarding continuing education credit to the participating teacher.

(3) Provisions should be made for exchanging ideas across areas and levels of instruction by conducting some portions of the inservice training in groups containing both elementary and secondary teachers.

(4) Portions of metric measurement inservice training should be conducted for separate groups of primary, elementary, and secondary teachers where specific information is needed.

(5) In order to give teachers an opportunity to have input in planning inservice programs and in order to give workshop planners needed information to design effective inservice programs, it is suggested that a teacher self inventory summary and an attitude scale be used. An example of such instruments may be found in Appendices D, E and F.

SCHOOL LUNCH PROGRAM

The nutritional goal of the school lunch program is to provide at least one-third of the daily dietary allowance recommended by the National Research Council for children of various age groups. Since measurement plays a major role in purchasing, preparing and serving food, lunch program personnel will find it necessary to understand the use of basic elements of the metric system.

Recommendations

(1) Because present federal regulations regarding minimal amounts of food components are written in customary measurement units, a new statement of policy describing the Type A lunch and the breakfast pattern is needed.

(2) It is suggested that the following publications be revised to reflect the use of the metric system.

a. Metric Planning Guide for Type A School Lunches, U.S.D.A. Food and Nutrition Service Program Aid—719

b. Recipe Card File "Quantity Recipes for Type A School Lunches", U.S.D.A.—1971, Program Aid—631

c. Food Buying Guide for Type A School Lunches, U.S.D.A.—1972, Program Aid—270

(3) It is recommended that appropriate metric devices and measuring instruments be purchased.

(4) It is recommended that the school lunch program help promote metric awareness. This might be done by displaying lunches with portions indicated in metric measurements or by writing appropriate articles for school newspapers.

Inservice for Cafeteria Staff

(1) Inservice programs are necessary for cafeteria staff—manager and workers—to become competent in using metric measurement as it pertains to purchasing, preparing, and serving food.

(2) It is suggested that a portion of the program for the annual state conference, regional conferences and local inservice programs of the School Food Service include general metric information, hands-on measurement experiences, and projects utilizing the metric system. These inservice programs should total four to six hours and be presented in two-hour time blocks.

(3) The following are suggested metric activities for inservice programs.

a. Given a recipe with metric measurements, determine the number of servings possible

b. Given a recipe with metric measurements, calculate the quantities of ingredients needed to increase or decrease the serving potential of the recipe

c. Using appropriate measuring instruments, find the capacity of certain containers

d. Make degree Celsius conversion stickons for oven temperature indicators

TELECOMMUNICATIONS

The need for knowledge of the metric system (SI) by the population of Virginia presents a unique educational challenge for telecommunications. Instructional television stations in the state can transmit metric information to large segments of the population. Two types of programs are recommended, one designed specifically for school systems and the other for the public.

Objectives for School Programming

(1) Regional School Contact Planning Committees (RSCPC), advisory groups which develop, review and recommend instructional television materials for transmission throughout the state, will conduct need assessments for metric education.

(2) The RSCPC will review and recommend programs for both purchase and dissemination. They will designate the appropriate instructional level and academic discipline(s) for each program.

(3) In accordance with the State Master Plan for Public Telecommunications programs produced will be made available to all stations through the RSCPC.

Objectives for Public Programming

Both educational and commercial television stations should be involved in communicating metric information.

(1) Public service announcements and awareness spots should be made available to commercial stations.

(2) The Superintendent of Public Instruction should request that a Governor's Committee on Metric Conversion be established.

(3) A media subcommittee of the Governor's Committee should be established to coordinate awareness and educational training programs presented through the media. These would include instructional, public, and commercial television, newspapers, and other print media.

TEACHER CERTIFICATION

Teachers need competence in measurement concepts appropriate to their subject area and grade level. It is recommended that by January 1, 1980, the metric system (SI) be included in instructional programs in Virginia Schools, and that teachers be competent in the use of the metric system by that date. The Division of Teacher Education and Certification should inform the appropriate institutions of higher education that SI units should be included in their teacher training programs and especially in the area of general education. Included in the appendices of this document are suggested test items to assist in evaluating competency in metric measurement.

STATE TESTING PROGRAM

At present, there is no provision for including metric competency tests in the State Testing Program. It is not anticipated that there will be any significant changes in the near future.

The broad needs of testing and evaluation of metric education should include assessment on a periodic basis, validation of teaching materials and strategies, and a timeline for implementation.

The following recommendations are suggested for the Standards of Quality Testing Program.

(1) During the period of transition, test items should be reviewed and changed to reflect increasing knowledge of students in metric measurement.

(2) Test items should be subjected to intensive analysis.

(3) Tests should be structured in a manner which will sample the students' knowledge of all aspects of the metric hierarchy.

(4) Metric references and skills should appear in minimum reading competency tests at both the elementary and secondary levels.

It is further recommended that the State Assessment Program include in all subject areas an appropriate sampling of metric skills. A state review committee should be organized to compile items related to metrics that might be involved in this program.

INSTRUCTIONAL PROGRAMS

There is little doubt that effective implementation of the metric system will take place in individual schools. Both elementary and secondary educators have responsibilities for developing specific instructional programs to accomplish the objectives stated in this document.

The Metric Planning Committee has compiled the following recommendations for metrication within the various disciplines. The guidelines are NOT intended to be all inclusive but rather to provide a starting point for curriculum planning. It is hoped that each person working in a given area will continue to seek ways to strengthen the measurement component of the curriculum.

ELEMENTARY EDUCATION

The International System of Units is the primary system of measurement used in most of the world. Students will graduate into a metric world; therefore, it is necessary for educators to aid them in developing appropriate measurement skills. To develop those skills and to encourage students to use metric measurement in their everyday lives, the metric system must be an integral part of the elementary school curriculum.

I. Program Development

A. Curriculum

1. Activities involving direct comparisons of objects (long, longer, heavy-heavier, more-less) and comparisons of objects to a non-standard measurement unit (the length of 4 paper clips is the same length as a pen) should precede those using standard units of measure
2. Instruction in the history of measurement and the metric system should be provided
3. The commonly used units of metric measure (metre, litre, kilogram, degrees Celsius) and the quantities they measure (length, capacity, mass, temperature) should be an integral part of the curriculum
4. Although the units of measurement for time and money will not change, they should be included in measurement activities
5. Because learning requires active participation by the student, a laboratory approach to teaching metric measurement is desirable
6. Estimation should be included in measurement activities
7. Actual measurement experiences are necessary to the learning of measurement skills. Such activities should begin with linear measure. (At the primary level, a centimetre ruler may be more suitable than using a metre stick for measuring)
8. Instruction should place greater emphasis on computation with decimal fractions than on computation with common fractions
9. A gradual introduction to metrics will encourage a natural feeling for metrication

B. Materials

Essential materials needed to effectively teach metric measurement are

1. Metre sticks
2. Tape measure (possibly 150 cm)
3. 20 or 30 cm ruler for each student
4. Balances with gram and kilogram weights
5. Bathroom scales
6. Trundle wheel
7. Caliper
8. Graduated litre containers
9. Different shaped containers which have capacity of one litre
10. Models of one square decimetre, one square metre, one cubic decimetre
11. Interlocking cubes
12. Celsius thermometer

Almost all materials listed above may be made in the classroom, thus providing an excellent teaching activity.

All metric materials purchased should be carefully evaluated for accuracy and consistency.

II. Teacher Education

All prospective teachers should be taught the SI metric system of measurement. Inservice

for school faculties should be provided by persons who are familiar with the system. All teachers should be encouraged to join organizations that will provide information about metric education and curriculum development.

III. Activities and Strategies

Metrics should not be taught as an isolated topic, but should be incorporated in the entire school curriculum. The following are suggestions by subject area for activities and strategies to help the students learn and "think metric".

Art

A. Make posters to display uses of the metric system or the relationship of common objects to metric units of measurement

B. Plan and decorate bulletin boards in metric displays

C. Use metric specifications to construct mobiles of metric symbols

D. Create cartoons about metric measure

Health

A. Use metric tape to measure height

B. Use metric scales to measure weight

C. Invite the school nurse to demonstrate the use of the metric system in the administration of medicine

Mathematics

A. Readiness activities

1. Match—sort
2. Compare objects—(lighter-heavier: longer-shorter)
3. Combine—(Combine like objects or quantities—two books, three glasses of water—and observe the relationship of the new quantity to each of the originals)
4. Use non-standard units of measurement to develop the rationale for using a standard unit. (Use the length of a paper clip, a pencil, or a book edge to measure the length of a piece of drawing paper)

B. Length

A number of activities that emphasize the decimal nature of the metric system should be included

2. Make a metric tape measure using available materials (adding machine tape or hemming tape)
3. Measure the height of each child in class and make a graph of the heights. Make other measurements, for example, measurement of the wrist, length of the arm and size of the neck
4. Use the trundle wheel to measure distances in the school environment
5. Cut a piece of tagboard the same length as each child's stride. Label each stride card using the child's name. Let the children measure specific distances using the stride cards

C. Mass

1. Determine the weight of each child
2. Estimate mass by holding objects; weigh them to find the actual mass

D. Capacity

1. Prepare a water table in the classroom (for rooms without a sink) for children to use in activities dealing with capacity. Provide a variety of shapes of containers to be used for litre measurement
2. Demonstrate the relationship of the mass of a litre of water to a kilogram

E. Temperature

1. Prepare posters indicating degree Celsius temperature ranges for hot and cold, normal room temperature, and freezing-boiling
2. Prepare charts to record daily room temperatures in degree Celsius

F. Time

Develop the concept of time beginning with the hour. Extend the concept to the minute as the students progress

G. Make a collage or mobile using the metric measures

H. Shopping activity—Make cards representing item labels and including metric measurement. Have the students sort the cards and put them into appropriately marked (metre, litre, kilogram) shopping bags (bottle of ginger ale would be put in the bag labeled litre)

I. For additional activities refer to the appendices of this publication

Physical Education

A. Use metric measurement for measuring distances, heights and weights for field day activities

B. Paint hard surface playgrounds to show metric measures for jumping, running, ball throwing, and other field or track activities

C. For additional activities see "Metric Olympics" in the appendices of this publication

Reading

A. Develop a list of metric terms; study the prefixes and symbols
B. Make hidden word games using metric terms
C. Develop metric puzzles

Science

The metric system should be used in any experiment involving measurement

A. Plant seeds (beans or peas) and record the height daily for two weeks after germination. Plant seeds and place in areas of varying amounts of light to compare growth patterns
B. Measure, at two month intervals, the height of children in the class
C. Make a daily log of the temperature inside and outside the classroom. Use these to make posters illustrating appropriate outdoor activities and temperatures, comfortable room temperatures, etc.
D. Determine the temperature in several locations throughout the school (temperature may vary near windows and doors)
E. Provide containers that are clearly marked in metric units of capacity for use in experiments dealing with capacity
F. Compare the capacity of cylindrical containers having congruent bases, but different heights
G. Compare the capacity of cylindrical containers having different diameters, but the same heights
H. Have students construct a 50 ml graduated measuring device
I. Compare the mass of different classroom objects by sight and touch; then verify using a balance

Social Studies

A. Use metric measurement in developing map skills
B. Study the history of the SI metric system
C. Research the use of the metric system in the United States and discuss existing timelines for conversion to metrics

ADULT EDUCATION

Adult education encompasses all subject matter areas. Recommendations concerning metrication in the individual subject areas also apply to adult education. Instructional emphasis and methodology may vary somewhat because the students are adults. The following are suggestions for developing an instructional program in metrics that would be suitable for adults.

I. Objectives of an Instructional Program in Metrics

A. To provide a rationale for use of the metric system in the United States

Explanations should involve a discussion of the necessity for conversion to the metric system and the simplicity of the metric system as compared to the current system of measurement

B. To help develop a positive attitude toward metrics

There is no better way to develop a positive attitude in adults than to make them feel that their personal lives will be benefited by the change to metrics. Thus, the activities in which the adults participate to gain knowledge of metric must be related to personal experiences and involvement

C. To help students understand that conversion to the metric system will be a gradual process

Many adults do not like sudden changes in their lifestyles. Thus, they need to be reassured that there will be no sudden switch to metrics. They must understand that the change will be made gradually and that they will be prepared for it

D. To assure adults that schools are not forcing metrics on them

Once the rationale for metrics is understood, adults should also understand the school's responsibility for carrying out the program. However, if they have the opportunity to participate in metric programs and activities they can better realize that the schools are providing a necessary service

E. To indicate that metrics is a way of the future

Schools attempt to prepare students to deal with future developments. Therefore, since

the metric system soon will be the primary system of measurement, schools are beginning to prepare now

II. Use of Practical Measurement Activities

The measurement activities suggested in various subject areas also can be used in adult education. "Hands-on" activities that deal with practical applications of the metric system are most appropriate

III. Designing Appropriate Metric Activities

A. Activities should be appropriate for adults. Although the class may be operating at a low achievement level, the activities should be adapted for the adult student. What may be an appropriate activity for an elementary student may not be appropriate for an adult. Activities must be those that will encourage an attitude of acceptance by adults

B. Emphasis should be on the metrics used in everyday living. Activities should involve practical experiences with which adults are familiar

IV. Application of Metric Measurement to Daily Activities in the Classroom

When measurement is involved in a class activity or discussion, no matter what subject is being taught, metrics should be included. For example, in a food preparation class, metrics can be used in a recipe. In a social studies class when students are involved in learning to read maps, kilometres should be used rather than miles when determining distances

V. The inservice section of this publication is appropriate for use with teachers of adult education classes

AGRICULTURAL EDUCATION

In agricultural education, applications of metric measurement are rapidly becoming evident. Teachers and supervisors will need to become aware of the metric system and its implications for agriculture.

I. Program Development

A. Curriculum

1. Students will receive instruction in the background and rationale for moving to the metric system
2. Instruction in weights and measures will utilize metric units
3. Students placed in supervised occupational experience programs related to agricultural business or processing will receive instruction in the metric system as it relates to their work
4. Young farmer and adult education classes will include instruction in metrics as needed

B. Materials

1. It is recommended that
   a. All new lesson plans developed by Virginia Polytechnic Institute and State University and Virginia State College should include metric usage when measurement is involved
   b. Course guides and lesson plans should be revised to include metric measurement where applicable
   c. New audiovisual material containing accurate metric information should be selected
   d. Current instructional aids should be updated to include instruments for metric measurement
   e. Instructional units on applications of the metric system to agriculture should be added to the preservice program in agriculture education
   f. Tools and equipment should be updated and replaced as necessary

II. Teacher Education

A. Instructors should

1. Develop awareness of the need for the metric system
2. Become aware of the simplicity of the metric system
3. Identify current uses of the metric system
4. Realize the importance of measurement ideas and skills
5. Review the need for standardized measures and the concept of accuracy and precision
6. Review the International System of Measurement: numeration system relationship, prefixes, symbols, physical and comparative referents

7. Become aware of commonly used metric units
8. Develop awareness of various consumer applications
9. Learn to read instruments which are metrically scaled
10. Become aware of specialized applications of metric measurement
11. Develop a criteria for selecting instructional materials pertaining to metric measurement in agriculture
12. Identify measuring instruments used in specific areas of agriculture
13. Become familiar with the "do's" and "don'ts" for teaching SI units

B. An inservice program as outlined above will be conducted for the state staff in agricultural education

C. A three-hour workshop will be held during the July agricultural teachers conference and will address itself to presenting a rationale for moving to the metric system, describing the metric system and identifying basic information

D. It is recommended that area supervisors offer a one-hour graduate credit course for agricultural teachers

E. As indicated, participants in an inservice program should have "hands-on" experience with metric measurement. The following activities are suggestions

1. Estimate and verify the dimensions of a field or enclosed area
2. Select the appropriate units of measurement and determine materials necessary to construct a sawhorse
3. Develop a metric measurement scale for a table saw
4. Measure objects or quantities for length, mass or capacity
5. Draw a floor plan to scale
6. For additional activities refer to the inservice section in this guide

III. Activities and Strategies

A. It is recommended that the student be able to

1. Identify the units of the metric system commonly used in agriculture
2. Solve word problems using metric measure
3. Read various metric instruments
4. Make estimates, and measure in centimetres, millimetres, metres
5. Estimate distance in kilometres
6. Convert from one metric unit to another metric unit
7. Find the area of a region in hectares, square centimetres or square millimetres
8. Identify the appropriate SI unit for making given measurements
9. Estimate and measure capacity of containers
10. Find the mass of common objects
11. Determine the accuracy and precision of a measurement
12. Record daily temperatures in degrees Celsius
13. Solve problems involving metric units of speed
14. Solve problems involving metric measures and unit prices

B. In the specific subject areas of agriculture the following metric measurement activities are recommended

1. Agricultural Science and Mechanics I & II
   a. Measure the length, width, and thickness of boards
   b. Estimate the amount of fertilizer to apply to a specific area
2. Agricultural Production
   a. Calculate the amount of chemical to apply to one hectare
   b. Measure a land area
3. Ornamental Horticulture
   a. Maintain the proper greenhouse temperature (degree Celsius) for various plants
   b. Prepare two cubic metres of potting material
4. Agricultural Machinery Service
   a. Calculate the grain loss during the harvest of a given area of corn
   b. Calculate piston displacement in certain engines
5. Agricultural Business
   a. Calculate by metric units the prices of agricultural products

b. Calculate the transportation costs from producer to market

c. Calculate the amount of ingredients needed to mix one metric tonne of fertilizer having an analysis of 5-10-10

6. Natural Resources Management

a. Calculate the volume of stacked pulpwood

b. Estimate the volume of timber in a specific area

ART EDUCATION

Art teachers in Virginia have a responsibility to participate in the transition to the metric system. The main task will be to become familiar with basic metric information and utilize the metric system in every instance of measurement within the art program.

I. Program Development

A. Curriculum

The following are suggestions for utilizing metric measurement in various areas of art instruction

1. The metric system will be used as the predominant system of measurement in the art curriculum
2. Ceramics—Kiln temperatures should be designated in degrees Celsius. (A firing temperature of 1230 degrees Celsius (cone 6) is a part of the continuous scale where 0 degrees Celsius is the freezing point and 100 degrees Celsius is the boiling point.) When mixing glazes, utilize the metric measurement gram to indicate weight
3. Photography—The Kelvin unit (K) is used to designate heat of photographic lights and the millimetre designates film size (35 mm, 16 mm, 8 mm, etc.) and lens focal length (50 mm, 23 mm, 150 mm)
4. Mounting and matting artwork—Use centimetres and millimetres in determining sizes of materials
5. Crafts—Use metric measurements when measuring materials for macrame, weaving, and stitchery projects
6. Design—Utilize metric measurements when doing scale drawings for house plans, interior design, sets for plays, and scaled drawings for urban design projects
7. Art history—Present in metric units the measurements of architecture, paintings and other art masterworks
8. Graphics—Design sample labels and other graphics in dual measurements to aid in the transition to metrics

B. Materials

1. Replace yardsticks and rulers with mettre sticks and metric rulers as soon as possible. Replace paper cutters with ones marked metrically as soon as the budget allows. In the meantime, alter ruled guide to indicate metric units (grid on bed of cutter will have to remain in customary system)
2. The art teacher will be most directly involved with metric measurement when orders are placed for materials. While standard sizes and amounts of basic materials have not all been established, suggestions are offered in 3, 4, and 5 below to help the art teacher. To encourage suppliers to convert to metric measurements, art teachers should attempt to order supplies and materials with metric specifications.
3. Papers

The printing and publishing industries are examining standard paper measurements used in other countries, particularly those in Australia and Germany. It is probable that the United States will accept for general use an international standard for paper measurement. One being seriously considered is an International Standard Organization series which designates 11 different sizes. Each of these can be cut without waste from a large sheet designated A0, down to the smallest A10. A0 measures 841 × 1189 mm (33.1 × 46.8 inches). Each smaller size is obtained by halving the longer of the preceding sides and leaving the other side the same. Thus A1 is 594 × 841 mm, A2 is 429 × 594 mm, and A3 is 297 × 429 mm or an eighth of the area of the A0 sheet. The A4 size is 210 × 297 mm (8.3 × 11.7 inches). Although they probably

will not be used when a standard is adopted, the following are metric equivalents for current standard sizes

(228.6 × 304.8 mm) = 9 × 12 inches
(304.8 × 457.2 mm) = 12 × 18 inches
(609.6 × 914.4 mm) = 24 × 36 inches

4. Clay—The following relationships may be helpful in ordering or distributing amounts of clay

50 pounds is approximately 22 kilograms
5 pounds is a little more than 2 kilograms
4 pounds is a little less than 2 kilograms

5. Paints—Approximate relationships listed below may be helpful to the teacher in deciding on quantities of paint

1 quart is approximately 1 litre
1 pint is approximately 500 ml
½ pint is approximately 250 ml
1 fluid ounce is approximately 30 ml

II. Teacher Education

A. It is recommended that art instructors enroll in workshops to gain general knowledge of the metric system, knowledge of applications, and criteria for selecting instructional materials

B. Suggested workshop content

1. Introduction, justification, and impact
   a. Historical background
   b. Rationale for conversion to the metric system
   c. Current consumer applications
   d. Areas of everyday life that will change
   e. A film presentation may be used to introduce or illustrate several of the topics listed above. For suggestions refer to the bibliography of this report
2. Basic terminology—Metric units of length, volume, mass and temperature
3. Applications for use of the metric system in art
4. Posters illustrating metric system
5. Criteria for selecting instructional materials
6. For more information refer to the in-service section of this publication

III. Activities and Strategies

A. Design posters and bulletin boards to illustrate major differences between customary and metric measurement units

B. Design posters or paintings depicting the history of weights and measures

C. Design sample labels and other graphics in dual measurements to aid in the transition to metrics

BUSINESS EDUCATION

At a first glance the effect of the conversion to the metric system may not be as obvious in business education as in certain other disciplines such as science and mathematics. It is evident however, that Business Education must identify metric competencies required by the business community and provide appropriate instruction. In other countries that have converted to the metric system, business teachers and office workers have experienced little difficulty in making the transition.

I. Program Development

A. Curriculum

1. A background and rationale for moving to the metric system is needed for students and teachers
2. Course outlines for business education should have appropriate supplements which properly treat metric measurement
3. Office procedures that are affected by metrication must be updated in job-preparation programs
4. Accounting and recordkeeping activities will not undergo significant changes because they deal with financial data already in the decimal system
5. Instruction in the appropriate style of writing metric terms and symbols should be included in the business curriculum

B. Materials

1. Examine existing materials to replace customary measurements with metric measurements
   a. Business mathematics-related sub-

jects deal with many applied problems including linear and volume measurement

b. Typewriting-related course material includes minimal reference to measurement, usually confined to inches

c. Visual aids, supplementary materials, and workbooks will need to be adapted where necessary

2. During the transition, it will be necessary to have a supplementary metrication kit available for classroom use

II. Teacher Education

A. Preservice teacher education programs should include metrication

B. Local divisions should conduct inservice programs related to metric awareness and implementation

C. A plan for expanding metrication beyond teacher education programs is needed at the post-secondary level

D. Professional associations should devote part of their programming to metrication

III. Activities and Strategies

A. Form a committee of business teachers to adapt curriculum business and industry materials to the metric system

B. Compile a list of metric skills necessary for employees of local business and industry to determine employee requirements as they relate to the metric system

C. Have students, with the instructor's guidance, make the appropriate measurement changes in textbooks and reference materials

D. Provide the student with a writing style guide for metric terms

E. Provide opportunities for students to solve problems involving metric measurement

F. Provide a conversion table for students

DISTRIBUTIVE EDUCATION

Distributive education teachers and coordinators have a responsibility to participate actively in developing community awareness of the metric system and in developing a positive attitude toward its use. In addition, teachers must provide instruction directed to metric competencies necessary for functioning in the metric community.

I. Program Development

A. It is recommended that a statewide Distributive Education Metric Committee be established for the purpose of making decisions concerning metrication in distributive education on adult and high school levels

1. The committee should be made up of representatives of business, adult specialists, teacher educators, teacher coordinators, State Department of Education personnel, and the curriculum specialists

2. Responsibilities of the committee should include

a. Identifying inservice and preservice training to help teachers develop metric competencies and provide effective leadership in metrication

b. Reviewing and revising existing curriculum materials (print and audio-visual)

c. Recommending appropriate revisions of curriculum guides

d. Developing a list of recommended subject matter reference books which reflect the use of the metric system

e. Determining units of measurement that are unique to each of the several areas of marketing and distribution

f. Compiling a timetable which reflects the intent of the business community to change to the metric system

II. Teacher Education

A. Inservice education program for Distributive Education (high school and adult)

Purpose—to provide through inservice training awareness of the metric system of measurement and its place in the distributive education program

Recommendations concerning inservice education for high school distributive education coordinators will be made to comply with guidelines suggested by the Division of Vocational Education. Consideration should be given to the Five Year Improve-

ment Plan for Vocational Education, which includes a goal and strategies for implementing a system of measurement with emphasis on the metric system

It is recommended that the inservice section of this publication be used for developing inservice programs for distributive education

B. Preservice education program for distributive education

Refer to "Suggestions for Implementing Metrication in Vocational Education"

III. Activities and Strategies

A. Suggested activities for Distributive Edution

1. Discuss the possible effects of metrication in the departments of a large store (clothing, appliances, hardware, candy, home furnishings, cameras, drugs and the like)
2. Role-play a gas station attendant giving information in metric units to a customer pertaining to distances, amounts of gasoline or oil, tire sizes
3. Ask students to imagine they are buyers for a store of their choice. (Discuss possible advantages and disadvantages of converting to the metric system of weights and measures)
4. Discuss situations involving linear measure, square measure (area), capacity (volume), mass (weight), time and distance

Examples

Linear measure —Lumber, fabric
Area —Floor coverings, lawn and garden supplies
Capacity (volume)—House and garden supplies, medicines, gasoline, dairy products
Mass (weight) —Produce, meat products, grain products

B. Distributive Education Metric Committee suggested timetable

A distributive education metric committee should be established by September 1, 1977, and work on the following timetable

	(to be completed by)
1. Determine units of measure unique to areas of marketing and distribution	January, 1978
2. Obtain a timetable of businesses converting to the metric system	July 1, 1978
3. Determine the role of distributive education in assisting the business community to implement the metric system	August, 1978
4. Prepare a list of recommended metric materials	September, 1978
5. Revise or develop new curriculum guides	August, 1979
6. Inservice training	September, 1979
7. Initiate instruction in the use of the metric system at the adult, preservice, and high school levels	Fall, 1979

DRIVER EDUCATION

Driver education teachers must accept responsibility for incorporating appropriate metric units and terminology into their programs.

I. Program Development

A. Curriculum

1. Instruction in the use of metric measurement will be an integral part of the curriculum
2. Major changes will occur in the following areas
   a. Units commonly used in driver education: kilometre, metre, centimetre, cubic centimetre, kilogram, degree Celsius, kilopascal, kilometre per hour
   b. Reading metrically scaled instruments

c. Estimating distances in kilometres
d. Measuring stopping distances
   1. Reaction time
   2. Braking distances
e. Measuring following distances--perceptional skills
f. Equipment—Simulators and response systems
g. Automobile—Engine and tire sizes, fuel consumption
h. Interspersed laboratory phase

B. Materials
1. Review existing materials and adapt as needed.
2. Materials for special education students are available from the Woodrow Wilson Rehabilitation Center and the Schools for the Deaf and Blind at Staunton and Hampton
3. In evaluating new materials attention should be given to sections including measurement
4. Until new additions are available, textbooks should be supplemented with conversion charts and tables
5. Audiovisuals (refer to the Annotated Bibliography of this publication)

II. Teacher Education
A. Activities related to driver education instruction should be included in basic metric inservice programs
B. Driver education teachers should participate in metric education programs offered through state and regional conferences. Sectional meetings of the Virginia Association for Driver Education and Traffic Safety (VADETS) held in conjunction with the Virginia Education Association (VEA) should be attended
C. For additional information regarding teacher education programs, see the inservice section of this publication

III. Activities and Strategies
A. It is recommended that students be able to
1. Identify and apply commonly used components of the metric system
2. Read various metrically scaled instruments
3. Use kilometres and metres to determine distances
4. Use kilograms in determining the cost of an automobile license which relates to the weight of the vehicle
5. Use degrees Celsius in relation to engine maintenance and temperature
6. Solve problems involving metric units of speed
7. Solve problems involving metric measures and unit prices

B. The following activities are suggested for students
1. Convert mileage, distances and highway signs to metric units (use rounded units)
2. Determine kilometres per litre of gasoline for a specific vehicle
3. Write questions that could be included in state driver's test to evaluate a driver's knowledge of the metric units used in motoring
4. Investigate and report on the United States' use of the metric system as it relates to the foreign car market and servicing of foreign cars
5. Solve problems relating to braking distances

ENGLISH EDUCATION

Because the metric system is a language, the implications for English instruction are both obvious and real.

I. Program Development
A. Curriculum
1. In writing, students should be encouraged to use metrics whenever possible
2. Instruction should be provided in the appropriate style for writing metric terms and symbols
3. When possible writing and speaking assignments should focus on metric usage
4. Reading activities should increase skill in using metrics and knowledge about the metric system

B. Materials
1. Information about metrics should be included in existing materials
2. Materials considered for purchase should

be evaluated for appropriate use of metric units and symbols

II. Teacher Education

A. English teachers will need inservice training to develop specific activities which will promote metric awareness and help students learn to use the symbols of the metric system

B. Professional organizations should focus on metric awareness

C. English teachers should be especially alert for ways to use their communication skills to assist other teachers and people in the community to understand and manipulate the language of metrics

III. Activities and Strategies

A. Writing

1. Encourage students to develop writing skills by taking part in school and community metric-awareness projects such as the following
   a. Preparation of materials such as flyers, posters, or pamphlets for community distribution
   b. Writing a script for a television show dealing with metrics
   c. Writing news articles about metrics for school or community newspapers
2. Focus on metrics in writing activities such as
   a. Writing personal experience essays in which the student explains some experience he has had with the conversion to metrics
   b. Producing a class newspaper about the metric system
   c. Writing a summary of or a reaction to media treatment of some aspect of metrics
   d. Writing reports of some aspect of metrics: the linguistic history of a metric term; the history of some other nation's conversion to metrics; or a biographical study of an individual of importance in the development of the metric system
   e. Writing a humorous essay treating some situation which might arise from metrication
   f. Writing papers based on the rhetorical forms such as definition, classification, or comparison-contrast using some aspect of metrics as subject matter
3. Provide an appropriate and consistent style for writing metric terms and symbols

B. Reading

1. Provide practical reading experiences with emphasis upon the interpretation of metric symbols and terms. Reading of maps, globes, road signs, directions, package labels, and other expressions of popular culture may be incorporated into various units of study
2. Provide a variety of reading materials at all readability levels to enable students to develop an interest in, an understanding of, and a familiarity with the metric system. Biographies, histories, "how-to" books, trade books, and novels are examples of books that could be used
3. Provide practical learning experiences which require students to read and examine critically newspaper and magazine articles, speeches, and similar materials, concerning all aspects of the metric system
4. Draw attention to metric terms and symbols that appear in literature
5. Provide practical learning experiences which require students to use library resources related to metrics

C. Speaking and Listening

1. Focus on metrics and metrication in the classroom and the community
   a. Individual public speaking assignments in which the speaker presents information live or via media such as radio or television
   b. Group discussions such as the problem-solving discussion, or other group discussions in which the primary concern is collecting and sharing information
   c. Individual or group speaking assignments in which metrication is explained and advocated to the community
2. Focus on metric measurement in the use of media equipment (radio and television production equipment)
3. Involve students in oral interpretation, theater, creative dramatics, radio and television, and other areas in which

metrics may serve as subject matter

4. Encourage home and classroom viewing of television programs which deal with metrics
5. Teach skills and methods which will allow students to analyze classroom and community presentations concerning metrics
6. Teach acceptable pronunciation of metric terminology

FOREIGN LANGUAGE EDUCATION

When learning about a foreign culture, a vital element of concern is the system of measurement used. Foreign language teachers are fortunate in that the metric system is not completely new to them. They will be able to share their knowledge with their students as the United States converts to "Le Systeme International d'Unites" (the International System of Units).

Personnel involved with bilingual education should study this section as well as other sections of this document for activities that are appropriate for their program. Consideration also should be given to using students, whose country of origin is one in which the metric system prevails, as student assistants or aids in planning and conducting metric activities.

I. Program Development
   A. Curriculum
      1. Instruction should emphasize the simplicity of the metric system
      2. Instruction should provide a brief resume of the history of the metric system
      3. Instruction should supplement the material in textbooks with metric-related activities
   B. Materials
      1. Examine existing materials for metric content and for instructional situations where metric activities may be added to the daily lesson plan
         a. Automobile—engine and tire sizes, tools, measuring fuel consumption
         b. Sizes of clothing
         c. Quantities of groceries
         d. Weather expressions (temperature, precipitation, wind velocity, barometric pressure)
         e. Cooking measurements and temperatures
         f. Sports terms and distances, including Olympic games
         g. Geographical measurements
         h. Personal measurements
      2. Adapt maps and charts to provide metric equivalents as needed.
      3. Evaluate metric content of prospective material.

II. Teacher Education
   A. An inservice program to provide teachers with a brief history and demonstration of the basics of the metric system is recommended
   B. For general information refer to the inservice section of this publication

III. Activities and Strategies

To increase metric awareness and understanding

   A. Have students measure and record the height, length and width of various objects in the classroom
   B. Have students record Celsius readings on a thermometer
   C. Use kilometre markers on maps, etc. to indicate various distances (Paris, Rome)
   D. Have students compare distances recorded in both customary and metric units
   E. Have students report on individuals such as Ampere and Pascal
   F. Discuss the contribution of the Greek and Latin languages to metric terminology
   G. As an illustration of the need for standardization in measurement compare the metric system with the system developed by the Romans of the first century A.D.
   H. Use language fairs, festivals, language week or similar programs to demonstrate the degree to which the metric system is an integral part of a foreign culture
   I. Discuss the origin and history of the metric system as it relates to a specified language and culture
   J. Utilize the history of the development of the Olympics as a means of metric involvement in the Latin classroom
   K. Display authentic realia such as a wine bottle, clothing with sizes indicated, imported food, posters with advertisements from foreign periodicals

HEALTH AND PHYSICAL EDUCATION

The move to metrics has many implications for health and physical education teachers. Therefore, persons in those areas need to become competent in the use of the basic elements of metric measurement. They have an obligation to integrate the metric system into their program wherever appropriate.

I. Program Development
   A. Curriculum
      1. A background in the rationale for moving to the metric system should be provided for students
      2. Students should receive instruction in the basic elements of the metric system and their implications for health and physical education
      3. Curriculum guides in health and physical education should be revised to reflect the use of the metric system
   B. Materials, equipment and facilities
      1. The following equipment will need to be adapted to the metric system
         a. High jump standards
         b. Pole jump standards—poles
         c. Tape measurements
         d. Gymnastic equipment
         e. Track hurdles
         f. Scales
         g. Thermometers
         h. Weights
         i. Mats—free exercise area
      2. Measurements of distance will need to be revised in facilities such as
         a. Courts
         b. Diamonds
         c. Playing fields
         d. Swimming pools
         e. Tracks
         f. Gymnasiums
      3. Existing materials should be revised to include metric measurement where possible
      4. Materials or equipment considered for purchase should be evaluated for metric accuracy

II. Teacher Education
   A. Health and physical education teachers will need the same basic training in metric education as other instructional staff members
   B. There should be an intensive inservice program for physical education instructors. It is recommended that the inservice section of this publication be used as a guide in planning such a program and that the program include "hands-on" experiences in measurement. Special emphasis should be placed on the following
      1. Length
      2. Mass/weight
      3. Temperature
      4. Volume/capacity
      5. Distance
   C. Additional inservice training should be planned for special groups and officials who are responsible for the measuring and lining of athletic fields and for performing other duties
   D. Awareness of the metric system should be encouraged by using both standard and metric measurements regarding height and weight of players
   E. The Virginia High School League will be asked to cooperate in the move toward metric measurement and will be encouraged to support changes in rules and procedures to conform to the metric system

III. Activities and Strategies
   A. In physical education, students should
      1. Use metric instruments to measure equipment and facilities such as balls, ropes, bats, playing fields
      2. Convert school records to metric measurement where applicable. (This will be necessary for comparing present records to future records which will be recorded in metric units)
      3. Use metric measurement for activities such as standing long jump, high jump, weight lifting, softball throw
      4. Determine personal measurements in metric units for school records
      5. Make charts showing comparative measurements of playing fields, scales, weight, temperature, tape measures
      6. Study the Olympic games that have used scoring based on metrics and show how our system can be converted to the metric system

7. Compare the mile to the kilometre and 10 yards to 10 metres
8. Write physical fitness records using metric measurements
9. Determine in litres the amount of water in swimming pools of various sizes

B. In health education, students should
1. In the areas of nutrition and consumer health, convert measurements of liquids to litres
2. Measure body and room temperatures in degrees Celsius
3. Measure height in centimetres and weight in kilograms
4. Study metric measurements in drugs, medicines, foods

HOME ECONOMICS EDUCATION

Conversion to metric measurement will affect each citizen and home manager. The Home Economics teacher has a responsibility to provide leadership in the transition to the metric system and instruction in the use of the metric system in daily life.

I. Program Development

A. Curriculum

1. Consumer and Homemaking Education

The present course guide for consumer and homemaking education is developed around the four family living areas: Consumption of Goods and Services in the Family, Cultural Development in the Family, Individual Development in the Family, and Management in the Family. The following are suggestions for revision

a. In the area of consumption of goods and services and management, behavioral objectives and student experiences should include metric measures

b. The individual development unit should include teaching the kilojoule in nutrition and use of metric containers in grooming

c. Specialized areas of instruction should include metric measures where appropriate

2. Occupational program content guides and the senior intensified programs should be revised to include metric measures. Program areas include: food services, clothing services, child care services, home and institutional services, and home furnishing services.

II. Teacher Education

A. Preservice

1. College students in teacher education programs should be included in inservice training area meetings
2. Metric terms should be included in the methods and materials classes

B. Inservice

1. All home economics teachers should attend a training meeting within their supervisory areas
2. Each area supervisor, with the assistance of the Vocational Advisory Council, should determine the number of meetings to be conducted in a geographical area
3. Area inservice training should be held jointly with the other vocational services. These programs could be presented in two sessions: the first, a joint session on general metric information; and the second, meetings of individual service groups for metric information pertaining to their areas
4. Part-time instructors of adult classes who are not full-time teachers and would not be involved in regular school classes shall be invited and urged to attend area inservice training meetings
5. It is recommended that permission be secured for participants to earn consumer education units for certificate renewal

III. Activities

Listed below are some areas in home economics which involve measurement. Activities in each area should utilize metric units

A. Temperatures

1. House and exterior surroundings
   a. Heating and cooling
   b. Sanitation and disease control
   c. Laundry
2. Food
   a. Food preservation and storage

b. Food preparation
c. Food production
3. Personal care
a. Bathing and shampooing
b. Infant care
c. Home care of the sick
d. Disease control
4. Clothing

B. Lengths and sizes
1. House
a. Lot and landscaping
(1) Unit cost
(2) Module cost
b. Building
(1) Blueprints
(2) Standard sizes of components for construction (windows, doors, bath tubs, kitchen sinks, laundry tubs)
c. Furnishings
(1) Furniture and equipment
(2) Linens
(3) Curtains, draperies and hardware
(4) Decorative accessories
(5) Wall and floor coverings
2. Food preparation
3. Personal measurements
4. Clothing
a. Sizes in ready-made clothing
b. Pattern sizes for clothing construction
c. Selection
d. Design
e. Construction

C. Capacity (liquid)
1. House
a. Water heaters and humidity control
b. Septic systems
c. Hot water central heating systems
d. Fuel consumption (heating and cooling)
e. Laundry equipment
f. Dishwashers
g. Water closets or commodes
h. Detergents for house care
i. Other products for house care (paint, insecticides, polishes, waxers)
2. Food
a. Preparation: standardization of recipes
b. Storage
3. Personal: containers for personal care items
4. Clothing care: cleaning fluids, spot removers, detergents
5. Home and personal accessories

D. Mass (Weight)
1. House
a. Lawn care products
b. Scales
c. Detergent powders and sanitizing agents
d. Fuel purchase and consumption for heating and cooling (wood, coal)
2. Food
a. Preparation
b. Production, purchasing and storage
(1) Vegetable gardening
(2) Food purchases and use
(3) Portion sizes
(4) Container sizes
(5) Unit pricing
3. Personal
a. Scales
b. Nutrition
c. Container sizes
d. Unit pricing
e. Cosmetics—perfume, sachets, soaps, face powder
4. Home and personal accessories

IV. Adult Education

Regular classroom teachers will be encouraged to assume some responsibility for teaching adult education classes

INDUSTRIAL ARTS EDUCATION

It is important that students be given an opportunity to use metric measurement in daily classroom activities. Metric measurement should be a normal part of industrial arts education. The basic measurement objectives for students are no different in industrial arts than in any other subject area.

I. Program Development

A. Major changes in the curriculum will occur in the areas listed below. Teachers should review course guides and outlines to determine changes needed in specific areas

1. Selection of the appropriate metric units for measuring length, area, mass, volume, and temperature
2. Estimation and verification with metric units
3. Determining acceptable error tolerance in metric units for mechanical drawing
4. Instruction emphasizing common metric usage and including laboratory activities
5. Applications requiring the use of a micrometre, vernier caliper
6. Land measurement
7. Applications including scale drawings in drafting and the use of metric charts and tables

B. Materials and Equipment
1. Instructional materials involving metric usage should be easy to read and understand, present everyday usage, and actively involve students
2. It will be necessary to construct or purchase measuring devices such as metre sticks and metric tapes
3. Equipment scaled in customary units should be recalibrated. This can be done by taping the appropriate metric scales over the customary scale. Use of dual scales should be avoided
4. Scales on all machinery and tools should be revised where practicable. Measurement scales on all new machinery and tools purchased should be in metric units

II. Teacher Education
A. Inservice programs for industrial arts teachers should include measurement experiences relating to instructional areas normally included in an industrial arts program
B. Inservice programs should include those topics and activities listed in the inservice section of this publication

III. Activities and Strategies
A. Construction
1. In working with maps, surveys, site plans, work drawings, assembly and detail drawings, use metric units
2. Survey school ground using appropriate metric measurements and plan
3. Design and construct a utility shed using metric measurement
4. Develop a metric detail drawing of a wall section

B. Manufacturing
1. Students should use metric measurement in manufacturing projects
2. Students should measure common items using a metric vernier caliper and micrometre
3. Students should practice using tapes, dies, and thread-pitch gauges

C. Communication
1. Develop a detail drawing of machine parts using metric measurements
2. Develop a newspaper layout using metric dimensions
3. Develop a bread board circuit using metric dimensions
4. Distribute developing solutions and ink in metric measures

D. Transportation
1. Measure the cubic displacement of a small gasoline engine
2. Measure force using a torque wrench or other appropriate metric tools
3. Measure fluids in metric units

MATHEMATICS EDUCATION

Measurement is a component of the mathematics curriculum. It is imperative that the primary system of measurement in the instructional program K-12 be SI. The use of the metric system offers an opportunity to reexamine the role of measurement in the curriculum and the instructional strategies used to introduce, develop, and apply measurement concepts. A commitment must be made by the mathematics educator to teaching measurement and the metric system.

I. Program Development
A. Curriculum
1. The teaching of measurement should be an integral part of the regular mathematics curriculum
2. The metric system should be used as the primary system of measurement in the mathematics curriculum
3. It is necessary for students to receive

instruction in and develop an understanding of decimal fractions at an earlier level in the educational sequence. Decimal fractions and computational skills with decimal fractions should receive greater emphasis. Operations with common fractions should be done concurrently with those involving decimal fractions

4. Proficiency requirements for high school graduation described in "Graduation Eligibility," Sections 2 and 4, in *Standards for Accrediting Secondary Schools in Virginia* should include a proficiency standard of measurement in the metric system
5. The same grouping notation should be used for all multi-digit numbers
6. Mathematics and science teachers should work together to establish a complete and consistent program of measurement for all students

B. Materials

1. State-adopted mathematics textbooks should include the metric system as the primary system of measurement and shall reflect curriculum changes necessary for the use of SI as the primary system of measurement by 1980
2. Supplementary and audiovisual materials should include the metric system as the primary system of measurement and must reflect curriculum changes necessary for the use of SI as the primary system of measurement by 1980
3. Existing textbooks and supplementary and audiovisual materials should be examined for metric content and supplemented where necessary

II. Teacher Education

A. Inservice and Preservice Programs

It is recommended that inservice programs in metric measurement for secondary mathematics teachers be a minimum of 10-16 hours, preferably scheduled in short activity sessions. Furthermore, it is recommended that certification requirements for secondary mathematics teachers be restructured to include a component in the fundamental concepts and the teaching of measurement with emphasis on the units of the metric system. Such inservice programs should be completed by June 30, 1980

It is generally agreed that mathematics teachers should assume major responsibility for teaching the metric system, while teachers in all subject areas should assume responsibility for teaching applications of the metric system. Consequently strong inservice and preservice programs are needed

1. Goals for Inservice and Preservice Programs

   The participants will

   a. Develop awareness of and the need for the use of the metric system
   b. Become aware of the simplicity of the metric system
   c. Realize that they already use some metric system measurements
   d. Reinforce their realization of the importance of and the extensive need for measurement ideas and skills
   e. Review what it means to measure, become aware of some of the basic assumptions concerning measurement, and review the need for standardized measures and the concept of accuracy and precision
   f. Review the International System of Units (Decimal numeration system relationships, prefixes, symbols, physical and comparative referents)
   g. Become aware of those components of the metric system which are commonly used
   h. Develop awareness of various types of consumer applications
   i. Extend understanding of metric measures which include the ability to read instruments which are metrically scaled
   j. Become aware of various specialized applications of measurement using the metric system
   k. Determine the measurement ideas, using the metric system which may be taught to students at various grade levels
   l. Review the appropriate writing style and instructional strategies for teaching the SI units
   m. Have experiences with measurement using the metric system

2. For additional information on inservice education refer to the section "Inservice Programs" in this publication

III. Activities and Strategies for Students

A. Student Objectives

The student objectives which follow are

meant to be neither all-inclusive nor minimal. It is hoped that the list will give guidance in determining measurement skills needed by the public in present-day society

The student will be able to

1. Identify those components of the metric system which are commonly used
2. Read instruments that are scaled metrically
3. Identify the most useful SI unit for making measurements
4. Change from one metric unit to another
5. Determine the accuracy and precision of a measurement
6. Estimate and measure in metres, centimetres, and millimetres
7. Estimate distance in kilometres
8. Estimate and determine the area of a region in square centimetres or square metres
9. Estimate and measure, using litres and millilitres
10. Estimate and determine the mass of objects, using kilograms and grams
11. Read and report temperatures in degrees Celsius
12. Solve problems involving metric units of speed
13. Solve problems involving metric measures and unit prices
14. Solve word problems involving metric measures

B. Student Activities

Students learn to think metric through experiences with metric units. Most educators agree that the "hands-on" approach is the best way to learn measurement. The teacher's prime responsibility in teaching the metric system is to provide opportunities for students to have direct experience using units of the system. Estimation as well as the actual measuring process should be emphasized.

The activities provide suggestions and models for development of activities and units on measurement and the metric system. Additional activities are listed in Appendix B of this publication.

1. Have the student estimate and measure his height, the width of his hand, the width of his index finger, the length of his foot, the length of the room, the length of the athletic field, the distance around the school building, the width of of a nickel, the length of a pencil
2. Have the student draw the outline of his hand or foot on cm^2 graph paper and determine its area; have the student estimate, measure, and compute the floor area of the room, a table top, a sheet of paper
3. Have the student keep a chart of the temperature (degree Celsius) in the classroom and out of doors for a number of days; have the student determine the temperature of boiling water and ice water
4. Have the student estimate and determine the mass of an apple, a penny, a book, a litre of water, balls of clay, and other objects found in the environment
5. Have the student estimate and measure the capacity of a milk carton, a medicine bottle, a coffee cup, and other containers
6. Have the student work with puzzles and games that are designed to reinforce an understanding of the units, prefixes, and symbols
7. Have the students construct a box with a capacity of 1 litre or determine the mass of a litre of water to demonstrate the relationship of units of capacity to linear units and mass

MUSIC EDUCATION

Measurement aspects of music are concerned with units which are unique to the nature of music as organized sound. Musical duration or time is measured in terms of beats which vary in speed. Volume or intensity of sound is measured in terms of decibels. Pitch level is indicated and measured by placement on a musical staff. None of these forms of measurement appear to be affected by a transition to the metric system. However, each teacher who comes into daily contact with pupils should be aware of the move to metrics and should adopt incidental measurement references to metric values wherever possible.

Listed below are some incidental uses of metrics in the area of music:

1. References to tube lengths and bell diameters in instrumental music
2. Oboe and bassoom reed construction and adjustment
3. Measurements of mouthpiece
4. Measurements for band and choral uniforms
5. Trip distances
6. Temperature-pitch correlations
7. References to sheet music size and storage boxes and envelopes
8. Measurements in planning for school music suites
9. Record sizes and tape lengths and speeds

Music teachers should make themselves aware of important changes in measurement education and contribute toward the integrating of learning experiences. This may be achieved through participation in inservice programs as outlined in the inservice section of this publication, by reading professional literature relating to measurement changes, and by attending special sessions featured at state and regional conferences designed to enhance the awareness of metric education. Once teachers become personally informed they will find many opportunities for reinforcement even though usage may be incidental to the specialized subject area being taught.

SCIENCE EDUCATION

Science teachers enjoy a unique position as far as conversion to a metric system is concerned. For more than half a century laboratory equipment has been calibrated in metric units. As a result, teachers have become familiar with the terminology and to some extent understand its relationship to volume, mass and length. It is likely teachers will need some training in the use of the metric system (SI) and will need to address certain curriculum changes.

I. Curriculum

A. Temperature Measurements

Teachers, especially those dealing with the life sciences, who refer to body temperature in the customary way, should become aware of and use the Celsius designation of 37°C when instructing students

In those instances where Fahrenheit-scaled measuring instruments are on hand, students would benefit from recalibrating the instruments to conform to the Celsius scale

B. Food and Body Measurements

Metric measurements frequently referred to in the life sciences, such as the mass of a cat or guinea pig, and the height of humans, make good reference points for estimating other mass and height measurements

When discussing consumption within the food chain care should be taken to refer to all masses in SI units

C. Force and Work Measurements

The terms, commonly used in eighth-grade materials, of pound force, kilogram force, foot pounds, and kilocalorie, should be replaced with the SI units, Newtons and Joules respectively

D. Linear Measurements

When great distances such as those from earth to moon or earth to sun are expressed in kilometres, the logical unit for long distances, it may be desirable to use scientific notation to simplify the expressed quantity. For instance, the distance from the earth to the sun is 155 000 000 km; using scientific notation that measurement can be expressed as 1.55×10^8 km

Earth measurements such as circumference, diameter and crustal thickness can easily be expressed in kilometres without resorting to scientific notation

All linear problems such as those involving acceleration should be expressed in metres or kilometres per unit of time, rather than the commonly used feet/sec. or m.p.h.

Comparative plant growth measurements are easily and accurately expressed in centimetres. Tree height and girth lend themselves to measurement in metres. Practice in associating units of measure with commonly recognized objects greatly enhances students' understanding of the metric system

II. Teacher Education

A. Since most science teachers have been trained in the use of a metric system, inservice training needs are not as great as in some subject areas. Many who are

knowledgeable concerning a metric system often have misconceptions about SI. They frequently use outdated units and symbols not contained in the International System of Units. For detailed suggestions on inservice programs, refer to the inservice section of this publication

B. Science teachers comprise an excellent pool of resource persons or instructional personnel to be used to conduct inservice training in other disciplines

III. Activities and Strategies

The best way for a student to develop competencies in metric measurement and to acquire the habit of "thinking metric" is through actual measurement activities. The science classroom—where space is available and measurement devices are easily accessible—is an excellent setting for such activities. The following lesson plan suggests a strategy that may be used in teaching metric measurements

Title: Basic Metric Measurement

Purpose: To gain skill in the use of metric measurement and metric instruments

Materials: Metre stick
Centimetre ruler
Gram balance
Beakers
Metre tape
Centimetre tape
Penny
Can of soup
Can of vegetables
Piece of fabric
Yarn (1 m)
Book

Containers: Empty milk carton
Empty soft drink bottle
Empty juice can
Empty soup can

Procedure:

Using the measurement materials above determines the length, mass, or volume of the containers and objects

Object	Mass	Capacity
1. Empty milk carton	___g	___ml
2. Empty soft drink bottle	___g	___ml
3. Empty juice can	___g	___ml
4. Empty soup can	___g	___ml
5. Penny	___g	
6. Can of soup	___g	
7. Can of Vegetables	___g	
8. Piece of Fabric	___g	length___cm
9. Yarn	___g	length___cm
10. Book	___g	length___cm

This exercise should be followed by a class session involving the estimation of the mass, volume, and length of objects not previously measured

Conclusion:

You can find the mass of an object using a gram balance. You can find the capacity of a container using a beaker or graduated cylinder. You can find the length of an object by using a metre stick, centimetre ruler, or centimetre tape. A quart milk carton holds approximately 1 litre. A penny weighs approximately 1 gram. One metre is a little more than one yard.

SOCIAL STUDIES EDUCATION

Social Studies teachers have an obligation to incorporate the metric system into their programs, K-12, wherever appropriate.

I. Program Development

A. Curriculum

1. Systems of measurement should be emphasized in social studies classrooms, wherever appropriate
2. The impact of metrics should be explored in light of both historical and contemporary influences on society
3. Efforts should be made to coordinate metric education in the social studies with other subject areas
4. Local curriculum guidelines or programs in the social studies disciplines should be updated or developed to reflect the use of the metric system of measurement

B. Materials

1. The criteria for selection and adoption of social studies textbooks by the State Board of Education will include appro-

priate emphasis on the metric system (SI). Local school divisions which elect to use instructional materials which do not appear on the state adopted list will be encouraged to adopt materials which incorporate the metric system of measurement

2. Consideration should be given by local school divisions to future purchases of other instructional media which incorporate the metric system
3. Future curriculum publications and related social studies materials prepared by the State Department of Education will incorporate the metric system of measurement, where appropriate
4. Future purchases of films in the social studies by the Bureau of Teaching Materials will reflect appropriate emphasis on the metric system of measurement
5. Real effort should be made by school divisions to convert local instructional tools currently in use to reflect the metric system of measurement (globes, charts, graphs, maps, atlases)

II. Teacher Education

A. Inservice and preservice education programs on metric education in the social studies should be conducted by local departments and grade chairpersons, K-12

B. Key personnel representing all areas of the curriculum, K-12, should participate in locally organized workshops on metric education

C. School divisions should consider conducting local non-college credit programs for teachers on topics relating to metric education

D. State and regional conferences will feature special sessions on metric education and social studies to enhance awareness of the metric system of measurement

E. Professional organizations will be encouraged to publish articles and exemplary lessons on the use of metrics in the social studies. In addition, it is recommended that portions of state and regional conference programs address themselves to metric education in the social studies curriculum

F. State education agencies will encourage teacher education institutions to include opportunities for students to become competent in using and teaching the metric system

G. Teacher education programs should be coordinated on a K-12 basis

III. Activities and Strategies

The following are suggested for classroom activities

A. Compare systems of measurement used by various cultures—Chaldean, Egyptian, Hebrew, Oriental, Aztec, Mayan, English

B. Trace the development of the metric system of measurement in the United States including first legalization of use in trade, economic reasons why the United States postponed conversion to the metric system, and recent legislative developments

C. Interview local industrial leaders on the impact of metrics on industry, including possible cost of conversion

D. Conduct a panel discussion on the role of the metric system in space exploration and the impact of space exploration on international relations

E. Conduct a panel discussion on the impact which metrics will have on international sports competition. This should include changes which will occur in various sports

F. Research the use of the metric system of measurement in industry, the military, medicine, oceanography, space exploration

G. Determine measurements of a classroom, hallway, or playground. Draw a scaled model in metric units

H. Using a metric scale, draw a map from home to school

I. Invite guest speakers who are from countries which use the metric system to relate their experiences in this area

J. Make a local map-bulletin board showing kilometre distances from students' homes to nearby places

K. Conduct a survey to determine the direct impact which the metric system of measurement will have on the individual consumer

SPECIAL EDUCATION

Special education students have educational needs similar to other students and their educational goals are the same. All students at one point or another in their lives will use measure-

ment. It is, therefore, paramount that instruction in the metric system of measurement be provided for those students.

Handicapped children do not always fit into neat well-defined categories with uniform characteristics. Rather, they possess significant individual differences. With this in mind, it is difficult to write a set of suggested activities that would be appropriate to any and all situations. The measurement component of the curriculum for special education will differ little from curriculum changes indicated in other areas of this document.

In providing for children in special education, consideration should be given to pacing and individualization and, perhaps, to restrictions on the amount of content to be memorized. Use of metric units should reduce the memory load for students. Decimal relations will facilitate pencil-and-paper computation as well as those with the calculator. Thus, integration of the metric system into the total curriculum will be of particular benefit to the special education program.

Special education should be provided for handicapped children in the *least restrictive* environment. The stages for developing measurement skills are the same for special education students as for other students. Their need for "hands-on" experiences in measurement is the same.

It is recommended, therefore, that the implementation of the metric system of measurement into the special education program be achieved through the participation in regular classes at both the elementary and secondary levels. Appropriate attention must be given, however, to the handicapped students at all times.

Students in Special Classes

In cases where students are placed in special classes and instruction in measurement is left to the special teacher, a well-organized program is necessary. The special teacher should work closely with the metric coordinator in his or her division in planning measurement activities. In school divisions where a metric coordinator has not been appointed, teachers in the mathematics department are good sources of information. Listed below are suggestions that should be beneficial:

1. A "hands-on" approach to teaching measurement, where feasible, should be employed
2. Only those units and prefixes that are commonly used (metre, litre, kilogram, degree Celsius, milli-, centi-, and kilo-) should be taught
3. Measurement activities should be brief and contain the fewest possible unfamiliar elements
4. Estimation and approximation should be part of measurement activity
5. Use physical representations to assist in solving problems. The transition from working with physical objects and counting to working with concepts and properties of measurement should proceed gradually and naturally
6. Use a multi-disciplinary approach to teaching the metric system. Activities should be incorporated in all of the students' educational involvements such as social studies, reading and others. Specifically, however, instruction in the metric system should be an integral part of instruction in mathematics
7. For suggested specific classroom activities, see Appendix B.

Teacher Education

Inservice metric training for special education teachers should be provided in the same programs used for elementary school teachers. Metric measurement can be used as content for training in how to individualize for special education students, and this might be justification for a metric course specifically for special education teachers.

Suggested content for inservice workshops for elementary teachers and special education teachers is listed in the inservice section of this publication.

TRADE AND INDUSTRIAL EDUCATION

Because trade and industrial educators are involved with in-plant and on-the-job training for industry, business, and commerce, they have an obligation to identify metric requirements needed by employees and to provide metric instruction in their training programs.

I. Program Development
   A. Curriculum
      1. Identification of metric requirements in specific fields will be necessary for curriculum planning
      2. The use of a dual system of measurement will be necessary as long as business and industry are using both; thus, instruction in the use of both systems is necessary
      3. A timetable for industry's conversion to

the metric system will be necessary in curriculum planning

B. Materials and Equipment
   1. Measurement revision will be necessary for
      a. Hand tools (e.g. tapes, scales, sockets, level, protractors)
      b. Dial indicators on equipment (e.g. lathe, planer, drill presses, table saws)
      c. Textbooks and reference books
      d. Descriptions of size or amount (e.g. lumber, metal, building studs, cement)
   2. Conversion of machines to metrics can be done inexpensively by placing calibrated tape over existing indicators
   3. A timetable for the conversion of equipment to metrics and for purchase of metric tools is needed
   4. When considering conversion, only those elements on the machines that indicate measurement need attention in the near future
   5. In purchasing new equipment, consideration should be given to equipment having varied capabilities

II. Teacher Education
   A. Local trade and industrial education instructors, supervisors, and principals should be involved in comprehensive inservice metric workshops
   B. All trade and industrial education personnel should meet the goals outlined in the inservice section of this guide

III. Activities and Strategies
   A. Survey local businesses, Chamber of Commerce, and government agencies to identify metric competencies required for employees
   B. Establish curriculum development projects designed to produce transparencies, texts, exercises, projects, and tests which teachers of industrial education can use in familiarizing youth and adults with metrics
   C. A theme, "Go Metric", could be incorporated into National Vocational Education Week to promote metric awareness

VOCATIONAL EDUCATION

Vocational education instruction should provide students with competencies in metric measurement necessary for marketable skills.

I. Program Development
   A. Curriculum
      1. State curriculum guides in vocational education should be revised to include the metric system of measurement
      2. The State Department of Education, Division of Vocational Education, should develop guidelines for metrication of curriculum materials and fund the development of only those materials which meet the guidelines
      3. Each vocational program area at the state level should develop an approved list of recommended subject matter reference books which include measurement in terms of metrics
      4. A community study should be conducted of the various suggestions and recommendations of each vocational program area developed at the state metrication planning meeting. A commonality of content should be derived and made available for inclusion in vocational mathematics programs. Content and considerations unique to a program area shall be incorporated into that program
      5. A timetable for industry's conversion to the metric system is needed in curriculum planning
   B. Materials
      1. The Division of Vocational Education should approve for state funding only equipment calibrated in the same units of measure as the equipment being used in industry
      2. The Division of Vocational Education should develop guidelines for purchasing vocational equipment which would guard against the purchase of outdated equipment with conventional measurement devices
      3. Conversion tables and charts should be developed or obtained for specific occupational areas
      4. Measurement scales on existing equipment should be relabeled in metric units for instructional purposes
      5. Charts and tables are needed for converting measurement scales on existing

equipment where relabeling is not feasible

6. Manufacturers and suppliers should be advised to make equipment available with the metric system of measurement for all vocational areas

II. Teacher Education

It is recommended that

A. State level inservice workshops be provided by the supervisory staff in all areas in Vocational Education

B. State level inservice workshops be provided by supervisory areas for each vocational program area

C. The Division of Vocational Education should sponsor a study to determine the units of measurement that are unique to occupational areas in vocational programs and distribute the results to teachers

D. Local vocational five-year improvement plans should include a plan for metrication

E. Local vocational programs should coordinate their efforts with local secondary mathematics and career planning by September 30, 1978

III. Activities and Strategies

A. Students learn to "think metric" by "doing metric". Specific student activities relating to metric measurement and usage will vary according to the vocational program area. However, students must be given direct experience in

1. Using the language and symbols of SI
2. Identifying most useful SI units and selecting the correct instrument for making certain measurements
3. Performing arithmetic operations that involve use of the metric system
4. Using charts and tables for conversion between the customary and metric systems of measurement

B. It is recommended that the metric system be taught as a separate measurement system

ANNOTATED BIBLIOGRAPHY

FILMS

A Metric America. 16 mm, color, 16 min. Hollywood, Calif.: AIMS, 1973. Cost: $215.00 (Appropriate for use with Jr. High, Sr. High, Adult) Available through the Bureau of Teaching Materials, Virginia State Department of Education.

The film is appropriate for the introduction of the metric system and for increasing awareness of the importance and necessity of the U. S. becoming a "metric nation". This film begins with a parable concerning an imaginary people called Wimples. It shows that the difficulties they experience with their cumbersome measuring system turn out to be the same as those experienced in the U. S. It introduces metre, litre, kilogram, and degree Celsius. It emphasizes the prefixes centi, milli and kilo. It concludes by describing the process of metric conversion and pointing out the many benefits.

Heroes and Heroines of the Metric System. color, 11 min. Xerox Films, 1975. Cost: $195.00 (Appropriate for Jr. High, Sr. High, College, Adult) Available through the Bureau of Teaching Materials, Virginia State Department of Education, beginning in September, 1977.

This film provides an overview of the metric units for length, area, volume, mass and temperature.

Metric Meets the Inchworm. 16 mm, color, 10 min. Hollywood, Calif: AIMS, 1974. Cost: $150.00 (Appropriate for Jr. High, Sr. High, Adult) Available through the Bureau of Teaching Materials, Virginia State Department of Education.

In this film a U. S. Customary inchworm meets the metric system of measurement. The film explores the basic components of the metric system. It demonstrates the logical relationships among the units of measurement and pokes fun at fear of metric conversion.

Metrics, Part I: History-Length-Decimals. Color, 11½ min. Doubleday Multi-media, 1975. Cost: $175.00 (Appropriate for Elementary, Jr. High, Sr. High, College, Adult) Available through the Bureau of Teaching Materials, Virginia State Department of Education.

This film presents the history of measurement. It introduces SI, the International System of Units, and the use of the metre and the six prefixes used to indicate large and small units of measurement. It shows the use of the decimal in metric computations and the impact of metric measurement on American business.

Metrics, Part II: Volume. Color, 11½ min. Doubleday Multimedia, 1975. Cost: $175.00 (Appropriate for Elementary, Jr. High, Sr. High, College, Adult) Available through the Bureau of Teaching Materials, Virginia State Department of Education.

This film presents the use of the metre, litre, and gram. In addition, it explains the use of the six common prefixes and introduces the relationship of linear units to units of capacity and mass.

Metrics, Part III: Mass-Temperature. Color, 9½ min. Doubleday Multimedia. 1975. Cost: $175.00 (Appropriate for Elementary, Jr. High, Sr. High, College) Available through the Bureau of Teaching Materials, Virginia State Department of Education.

This film presents the use of the gram, milligram, and kilogram to designate mass and demonstrates the use of the Celsius thermometer.

BOOKS, PAMPHLETS, AND OTHER MATERIALS

Arithmetic Teacher, Vol. 20, No. 4 (April 1973) Published by the National Council of Teachers of Mathematics.

The entire issue is devoted to metrication. Most of the articles provide background information on the metric system—what it is, how it was developed, and what advantages there are in using it. Some specific suggestions for teaching are also included.

Bielefield, Carole. *SI—A Metric Workbook for Teachers of Consumer and Homemaking Education*. Santa Ana, Calif.: Orange County Department of Education, 1976. $1.50

The material contained within this workbook is geared for the daily activities of the American home. It is not intended for use by mathematicians or scientists who would be seeking metric information in greater depth. The workbook is presented in a format which should be easy to use by instructors of Consumer and Homemaking Education.

In addition, the book contains transparency masters and classroom activities geared to daily measurement uses in the American home. It also contains a brief history of the metric system and an explanation of why the U. S. is going metric. It contains a list of sources of metric suppliers appropriate for use in the home.

Bitter, Gary C. and Charles Greer. *Mathematics Education Reports: Materials for Metric Instruction*. Columbus, Ohio: ERIC Information

Analysis Center for Science, Mathematics and Environmental Education, The Ohio State University, 1975.

Teaching measurement with the metric system is providing an opportunity for teachers to reassess how they teach measurement. It has also led to the production of a vast array of materials of all types. This bibliography indicates some of the instructional materials which are available, with pertinent information about each item.

Buffington, A. V. and M. L. Sohns. *The Measurement Book*. Sunnyvale, Calif.: Enrich, Inc. $12.95, 200 pages. (Catalog No. 44100: Enrich, Inc., 760 Kifer Road, Sunnyvale, Calif. 94086)

This book is a practical handbook on metric activities for the teacher to use with students K-3. It may also be used with upper grade students who are limited in their experiences with measuring. The activities were selected to give students the knowledge and skill needed to deal successfully with metric measure. They are developmentally sequenced to allow for an orderly presentation of measurement concepts.

California State Department of Education. *In-service Guide to Teaching Measurement (K-8): An Introduction to the SI Metric System*. 1975, 48 pages. (Copies may be ordered from California State Department of Education, Publications Order Section, P. O. Box 271, Sacramento, Calif. 95802) $1.25.

This guide includes curricula strategies and classroom activities based on the philosophy that measurement skills are best learned by engaging in measurement activities. This in-service model for measurement using SI units is much like the one that is recommended for use with pupils.

California State Department of Education. *Interstate Consortium on Metric Education Final Report*. 1975, 28 pages. (Copies may be ordered from ERIC Document Reproduction Service, P. O. Box 190, Arlington, Virginia 22210 #ED 103 282, Paper Copy (HC) $1.67 plus 25¢ postage)

This report includes twenty-three guidelines and principles to be used in developing quality metric education programs.

Edwards, E. L., Jr. *In-Service Guide to Teaching Metric Measurement*. Richmond, Va.: Department of Education, 1976. (Copies may be ordered from Harry L. Smith, State Department of Education, Ninth Street Office Building, Richmond, Va. 23216)

This publication was prepared to assist instructional personnel in re-examining the role of measurement in the curriculum. It provides suggestions for teaching measurement with emphasis on the metric system.

Hopkins, Robert A. *Metric in a Nutshell*. Tarzana, Calif.: Polymetric, 1976.

This book was written for the average person, including students and adults having little or no prior knowledge of the modernized metric system. The author has selected only the information needed to acquaint the reader with basic requirements for understanding and working with everyday metric. Each category of daily life has been considered. Shopping and comparing metric with the customary inch/pound is explained. In addition a section devoted to the family auto, metric in the kitchen, metric sewing and complete details for writing and using correct SI metric is given. Common U. S. to metric conversions are listed. This book is excellent for teaching. It will not only be of value to the public in general, but will be of considerable assistance to those beginning to teach or study the International System of Units (SI).

Hynes, Michael C. and Douglas K. Brumbaugh *Mathematics Activities Handbook for Grades 5-12*. West Nyack, N. Y.: Parker Publishing Co., Inc., 1976.

In this book you will find puzzles, games, and recreational activities as well as strategies for teaching the metric system. It includes group instruction plans and programs in which the students may be self directed.

Information on the Metric System and Related Fields, 6th Edition. Produced by NASA/Marshall Space Flight Center in cooperation with the USMA. $2.25. (Can be purchased from the U. S. Metric Association. Remittance must accompany order.)

This is a source of references for metric books, articles, audio-visuals, training aids, and tools.

Lefflin, Walter W. *Going Metric-Guidelines for the Mathematics Teacher*. (Grades K-8) Reston, Va.: National Council of Teachers of Mathematics, 1975.

The booklet encourages teachers to integrate the metric system into their teaching in a natural way and use the system whenever possible. The following information is available in the booklet: the history of the metric system, guidelines for teaching the metric system, and instructional materials and activities. The classroom activities and ideas involve using homemade materials.

Lindbeck, John R. *Metric in Career Education*. Peoria, Ill.: Chas. A. Bennett Co., Inc., 1975.

This book is designed to help teachers and students in career education programs learn something about metrics. A knowledge of metrics is very important to future careers. Many employers are already requiring that their employees know what the metric system is and how to use it.

The purpose of this book is to present metrics in an easily understood manner. While the text is not difficult, it does demand study and practice. Topics included in the book are: Introduction to Metrics, Metric Practices and Standards, Metric Drafting, Metrics in Metalworking, Metrics in Woodworking, Metrics in Power and Energy, Metrics in Graphic Arts, and Metrics in Home Economics.

The Metric Guide. Toronto: Ontario Institute for Studies in Education. 104 pages. (Order from: Ontario Institute for Studies in Education, 252 Bloor St. West, Toronto, Ontario M5S 1V6, Canada. Cost is $3.00, less 20% to educational institutions. Volume discounts are available.)

The Canadian publication is a revision of the former Metric Style Guide. While intended for educators, it is of value to all persons concerned with metric implementation.

Metric Measurement Activity Cards, Monograph No. 4. Birmingham, Michigan: Michigan Council of Teachers of Mathematics, 1974.

This monograph provides an introduction to metric concepts of length, area, and volume for students in the elementary grades. The activity cards included with the monograph use materials that can be constructed by teachers out of readily available raw material. Some of the material can also be student-made. The authors of this monograph believe in "hands-on" activity as fundamental to a clear understanding of measurement.

Metrics: The Measure of Your Future—A Parent's Guide to Homework. Published by Metric Education-ESEA Title III. A project of the Winston-Salem/Forsyth County Schools, 1976. (Copies available for 50¢ each.)

The purpose of this booklet is to make it easier for parents to help their children learn the metric system. It includes such things as a brief history of the metric system, and the relationships within the metric system.

Metrics, The Measure of Your Future—Metrics in the K-8 Curriculum. Published by Metric Education-ESEA Title III. A project of the Winston-Salem/Forsyth County Schools, 1976. (Copies available for $4.00 each)

This guide was developed with the philosophy that metric education become a part of the public school curriculum. Students must be equipped intellectually and attitudinally for the change to metrics. An integrated approach, utilizing the entire school curriculum, provides the base for a broad framework which encourages students to apply metric knowledge to everyday experiences. Learning must proceed from concrete involvement to abstract understanding.

The following information is included in the curriculum guide: broad goals, behavioral objectives by grade level and by goals referenced to the activities list, activities referenced to grade levels and the materials list of publishers, producers, and suppliers, and criterion-referenced student tests (K-8)

Nelson, Doyal and Robert E. Reys. *Measurement in School Mathematics, 1976 Yearbook*. Reston, Va.: National Council of Teachers of Mathematics, 1976.

This book provides ideas related to the mathematical and psychological foundations of measurement together with a wide variety of activities for learning and teaching fundamental notions of measurement. Included in the book is information designed to aid the introduction of the International System of Units (SI) as the basic measurement system in the United States and Canada. The book addresses itself to: (1) a number of divergent issues and problems associated with learning and teaching measurement; (2) measurement activities in high school mathematics: (3) a bibliography of materials and ideas for the teaching of measurement.

Trueblood, Cecil and Michael Szabo. "Guidelines for Evaluation of Published Metric Materials Curricula or Program," *Arithmetric Teacher*. To be published, 1977.

This article provides a set of assessment guidelines and procedures to assist school personnel evaluate the measurement component of an instructional program and select quality materials.

Trueblood, Cecil and Michael Szabo. Project IMPACT. Pennsylvania: Pennsylvania State University.

Materials from this project are designed to assist administrators and teachers in planning and supplementing metric education programs on the local level.

STYLE GUIDES

Metric Units of Measure and Style Guide. Boulder, Colorado: U. S. Metric Association, Inc., 1976. (Copies may be ordered from U. S. Metric Association, Sugarloaf Star Route, Boulder, Colo-

rado 80302. Single copy, $1.00, 2 or more, 60¢ each, package of 10, $4.00, package of 100, $35.00.)

The objectives of this book include: to describe the metric system of measurement and to show some of the advantages in its use over U. S. customary units. The book emphasizes usage and rules authorized and approved by the international organizations having responsibility for revising and updating the initial metric system to meet the needs of all nations.

U. S. Department of Commerce. *The International System of Units (SI).* NBS Special Publication 330. 1974 Edition, 49 pages. (Copies may be ordered from U. S. Government Printing Office, Washington, D. C. 20402, SD Catalog No. C13.10: 330/3, 80¢)

This is a definitive reference guide to correct SI usage. It is the translation of the French "Le Systeme International d'Unites".

APPENDICES

APPENDIX A

FREE METRIC MATERIALS AVAILABLE TO TEACHERS*

The following metric materials are available at no cost to teachers upon request from the respective suppliers. These materials have been screened by the METS Program for general acceptability, but have not been reviewed in depth. Accordingly, some errors or inconsistencies may have slipped past us. Several items listed below use the "er" spelling, but it was decided to include them in the list because of their overall value. Materials with serious faults, in our judgment, have not been included.

We hope that these materials will continue to be available and that they will be useful to you. As we learn of other free materials of value, we will keep you informed.

1. Department of the U. S. Army
   Distribution Division
   Fort Sheridan, Illinois 60037

   "Modernized Metric System" Poster (1973)
   Developed by the National Bureau of Standards—suitable for secondary students and adults.

2. Educulture, Inc.
   3184 "J" Airway Avenue
   Costa Mesa, California 92626

   "Think Metric U.S.A.—An Audio-Tutorial Mini Course," 1975
   A sample audio-cassette of selected excerpts and a student instructional manual from their audio-tutorial learning program, "Think Metric U.S.A."—suitable for elementary and secondary students and adults.

3. Federal Reserve Bank of Minneapolis
   Minneapolis, Minnesota 55480

   "The United States and the Metric System," Ninth District Exponent Number 10, 1976
   40-page booklet updates the history of metrication through 1975, reviews the pros and cons of metrication, and offers an examination of some of the problems associated with conversion along with means of relieving those problems—suitable for adult and possibly high school levels. Classroom copies available.

4. Field Enterprises Educational Corporation
   Merchandise Mart Plaza
   Chicago, Illinois 60654

   "Metric System/Weights and Measures"
   Reprint from The World Book Encyclopedia, 1976 sections on the "Metric System" and "Weights and Measures"—13 pages. (Unfortunately, the articles contain many conversion tables.)

5. JC Penney Educational Materials—Write your local store

   "Insights Into Consumerism: Moving Toward Metric," 1974 Packet includes:
   (a) Five pamphlets discussing our changeover to metric activities and duplicating or overhead projector materials
   (b) Poster—"The Language of Metric"
   (c) Script for radio/TV—"Moving Toward Metric"

   (Because the materials were produced in 1974, information on legislation is not up-to-date. Material discusses only liquid volume and assumes that volume is only measured in litres.)

   "The Metric Song"—Filmstrip available on loan for one week.

6. LaPine Scientific Company
   Department 05
   6001 South Knox Avenue
   Chicago, Illinois 60629

   Plastic metric ruler

   "Metric Handbook," a publication which contains activities and exercises for the classroom.
   (We were not able to review this handbook.)

7. National Bureau of Standards
   Metric Information Office
   Washington, D. C. 20234

   "Some References on Metric Information"
   Metric packet includes:
   (a) NBS Special Publication 389, "Some

*List prepared by Metric Education Technical Support Program, American Institutes for Research, P. O. Box 1113, Palo Alto, CA 94302

References on Metric Information," 1975

(b) "Brief History of Measurement Systems," 1975—With a chart of the modernized metric system on the back
(c) Poster—"All You Will Need to Know About Metric," 1974
(d) Pocket-sized, plastic metric conversion card
(e) Chart on metric conversion factors, 1976
(f) Plastic centimetre/inch rulers
(g) "Household Weights and Measures," 1975—Includes information on using the metric system in the kitchen
(h) "America Joins a Metric World," 1976 —Reprint from *Dimensions/NBS*

8. Ohaus Scale Corporation
29 Hanover Road
Florham Park, New Jersey 07932

"Recommended Lists of Equipment for Teaching the Metric System of Measurement," 1976

Booklet designed to help you select and use metric tools in grades K-8.

Lists of equipment are arranged grade-by-grade for schools of various sizes and budgets.

9. National Council of Teachers of Mathematics
1906 Association Drive
Reston, Virginia 22091

"Free Materials for the Teaching of Mathematics," August, 1976, NCTM update and guide to suppliers of math materials.

10. Prentice-Hall Media, Inc.
150 White Plains Road
Tarrytown, New York 10591

"When You Can't Give'em An Inch—Metrics Made Easy"

Literature about their metric program which contains a centimetre ruler calibrated in 10 cm units—suitable for bulletin board display.

11. Sears, Roebuck and Company
Consumer Information Service
D/703, Sears Tower
Chicago, Illinois 60684

"An Educator's Guide to Teaching Metrication," 1974

This guide was designed to help secondary teachers incorporate the metric system into different subject areas.

APPENDIX B

METRIC MEASUREMENT ACTIVITIES

ACTIVITY: Determining linear measure using the metric system

Equipment: Metre stick, metric ruler and tape

Procedure:

1. Estimate the:
   a. length of the room
   b. height of a table or desk
   c. length of your pencil (pen)
   d. width of the door
2. Verify your estimate by measuring.
3. Determine the difference between your estimate and the actual measurement. Were your estimates reasonably close?

ACTIVITY: Determining linear measurement using the metric system

Equipment: Metre stick, metric ruler and/or tape, nickel

Procedure:

1. Estimate the:
   a. width of your index finger
   b. width of your hand
   c. thickness of a nickel
   d. length of your foot
2. Verify your estimate by measuring.
3. Determine the difference between your estimate and the actual measurement. Were your estimates reasonably close?

ACTIVITY: Determining area using the metric units of measurement

Equipment: Sheet of cm^2 graph paper, pencil or pen

Procedure:

1. Identify the area of the smallest square on the graph paper.
2. Draw the outline of your hand or an irregularly shaped geometric figure on the graph paper.
3. Determine the area of your hand or the geometric figure.

ACTIVITY: Determining area using metric units of measurement

Equipment: Metre stick, metric ruler or metric tape

Procedure:

1. Estimate the area of:
   a. the room
   b. a table or desk top
   c. a sheet of paper
2. Verify your estimate by measuring and computing the area.
3. Determine the difference between your estimate and the actual area. Were your estimates reasonably close?

ACTIVITY: Using the° unit, degree Celsius, to indicate temperature

Equipment: A thermometer marked in degrees Celsius, a pail or bowl, ice water

Procedure:

1. Estimate the temperature of:
   a. the room
   b. ice water
2. Use the thermometer to determine the temperature of the room and ice water.

ACTIVITY: Determining mass using metric units

Equipment: A metric scale, mass pieces, paper clip, apple, book

Procedure:

1. Estimate the mass of each of the following:
   a. paper clip
   b. apple
   c. book
2. Use the scales to verify your estimate.

ACTIVITY: Determining the relationship between mass and capacity in the metric system

Equipment: A litre container, water, metric scale, a metric graduated container

Procedure:

1. Find the mass of one litre of water
2. Find the mass of 500 millilitres of water
3. Find the mass of 200 millilitres of water
4. Can you "guess" the mass of 1 millilitre of water?

ACTIVITY: Measuring capacity using metric units of measurement

Equipment: A metric graduated container, water, styrofoam coffee cup, drink can, milk carton, medicine bottle

Procedure:

1. Estimate the capacity of:
   a. a styrofoam coffee cup
   b. a drink can
   c. a milk carton
   d. a medicine bottle
2. Verify each of your estimates by measuring.

ACTIVITY: Determining the relationship between metric units for measurement of volume and capacity

Equipment: cm^2 graph paper, scissors, tape (cellophane or masking)

Procedure:

Construct boxes which would have the following capacities:
   a. 1 litre
   b. 1 ml

ACTIVITY: Approximating and verifying linear measurement using the metric system

Equipment: Metric ruler, paper, pencil

Procedure:

1. Draw without measuring, line segments with lengths of approximately:
   a. 15 cm
   b. 1 dm
   c. 25 mm
2. Measure each segment you have drawn to see how close the length of your line segment is to the given linear measurement.

ACTIVITY: Approximating and verifying mass using the metric system

Equipment: A metric scale, some type of modeling clay or putty

Procedure:

1. Make balls of clay which have a mass of approximately: (Do not measure)
   a. 1 g
   b. 100 g
   c. 1 kg
2. Weigh each clay ball to determine the actual mass.

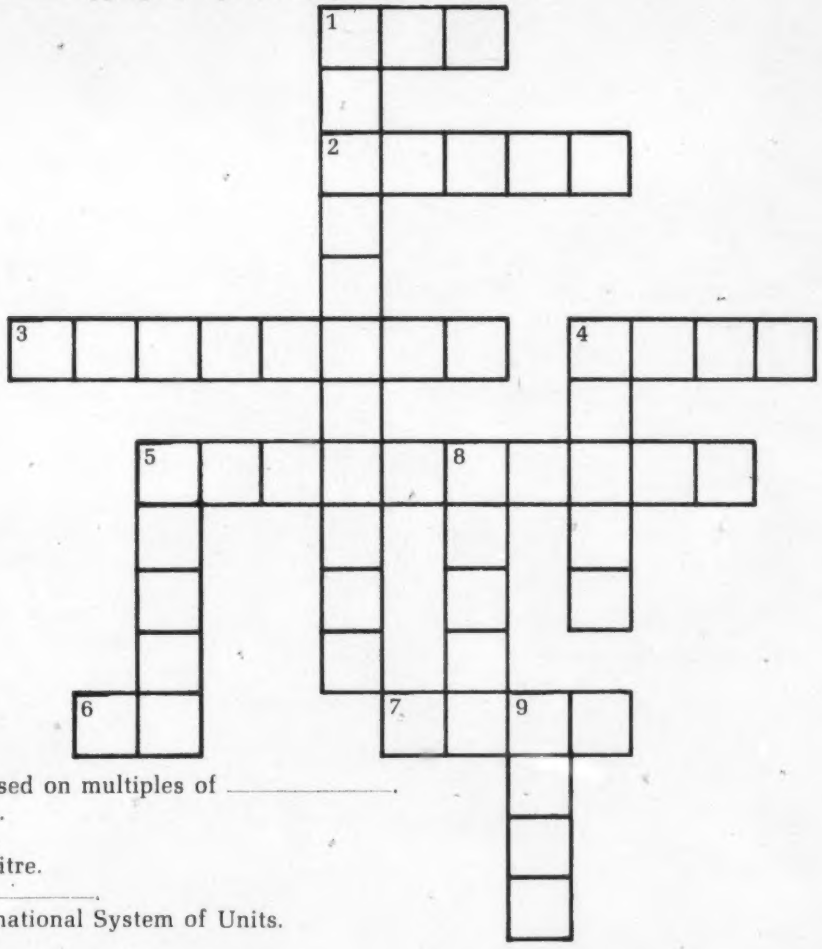
METRIC CROSSWORD PUZZLE

Objective: To review the more commonly used metric units and the prefixes.

Equipment: A copy of the crossword puzzle without the answers for each student.

Procedure:

Fill in the crossword puzzle with the appropriate prefixes, symbols or words.



ACROSS:

1. The entire metric system is based on multiples of _____.
2. The basic metric unit for length.
3. The basic metric unit for mass.
4. A quart is _____ than a litre.
5. A metre is divided into 100 _____.
6. The abbreviation for the International System of Units.
7. Metric prefix for 1000.

DOWN:

1. Degree Celsius is used for measuring _____.
4. The unit used in the metric system for capacity.
5. The prefix for 1/100.
8. The prefix for 1/1000.
9. The yard is _____ than a metre.

ACROSS:
1. Ten
2. Metre
3. Kilogram
4. Less
5. Centimetres
6. SI
7. Kilo

DOWN:
1. Temperature
4. Litre
5. Centi
8. Milli
9. Less

ME IN METRIC!

Height in centimetres is:

Estimate _____ cm
Measure _____ cm

Neck in centimetres is:

Estimate _____ cm
Measure _____ cm

Chest in centimetres is:

Estimate _____ cm
Measure _____ cm

Waist in centimetres is:

Estimate _____ cm
Measure _____ cm

Span Tip of little finger to thumb with fingers spread is:

Estimate _____ cm
Measure _____ cm

Hips in centimetres are:

Estimate _____ cm
Measure _____ cm

Distance from floor to knee is:

Estimate _____ cm
Measure _____ cm

Mass in kilograms is:

Estimate _____ kg
Measure _____ kg

ME IN METRIC!

Height in centimetres is:

Estimate _____ cm
Measure _____ cm

Neck in centimetres is:

Estimate _____ cm
Measure _____ cm

Chest in centimetres is:

Estimate _____ cm
Measure _____ cm

Span Tip of little finger to thumb with fingers spread is:

Estimate _____ cm
Measure _____ cm

Waist in centimetres is:

Estimate _____ cm
Measure _____ cm

Hips in centimetres are:

Estimate _____ cm
Measure _____ cm

Distance from floor to knee is:

Estimate _____ cm
Measure _____ cm

Mass in kilograms is:

Estimate _____ kg
Measure _____ kg

APPENDIX C

METRIC OLYMPICS—MEASUREMENT GAMES AND ACTIVITIES*

The fundamental objective of the series of activities which follows, is to present the metric system of measure to learners in a non-threatening manner via a game based laboratory approach. The students will hear the metric terms used properly while participating in team competition. No formal metric presentation is made during the activities but use of the terms and metric measuring devices facilitate later instruction.

Randomly divide the group into two or more teams of some convenient number (6-10 provide good activity levels). Strive to have the same number of students on each team. Every team must participate in each event. Although all team members will compete in some activities, no one will compete in all activities. When an event requires a limited number of participants from each team, "volunteers" are selected by the group. Suspense and hilarity can be inserted by choosing contestants before the event is described. In this case, any limitations as to dress or physical abilities would be stated prior to a team's designating its volunteers. Actually, a program can be established which has no special dress or physical requirements.

A spirit of competition can be generated by using a score board. Devise a system that awards a decreasing number of points as the team placement in an event decreases. For example, for three teams, first, second, and third places could be awarded three, two and one points, respectively. These points would be added and, at the end, the team with the largest total is the winner. There are sometimes advantages to going last and this can be spread around by having the teams do the next event in reverse order of finish from the last event. That is, if Team A finished first on event one, they go first on event two. If B was last on event one, they would go last in event two. In case of ties, an additional event can be used with only the tied teams participating. As events are used, you will need to make rule decisions commensurate with your group's disposition. Generally speaking, the sense of fun and fair play eliminates serious disagreements and your smooth reactions will do the rest.

The events to be used are dictated by your objectives. Metric Olympics was developed to provide examples of the following measures: linear, area, solid volume, liquid volume, and mass. This series of events has been done over 300 times with group sizes from 12 to 140. The age levels have been kindergarten through a group of 25 people whose average age was 75. Of course appropriate alterations might need to be made but the events are consistently well received.

If desired, a series of activities can be put together that would deal only with linear measure. The following activities can be combined to meet either of the forms mentioned. Similarly, events could be compiled to stress other areas of emphasis. The first six Metric Olympics activities can readily be done within an hour with a group of 30 students.

Standing Broad Jump. Participants must be able to jump for this event. Since a contestant might land in an awkward position, appropriate dress should be considered. Each team selects four (the number could vary) "volunteers" and then the event is named and the rules defined.

Several metre sticks are placed end to end on the floor forming a line segment. All jumpers use a two-foot take off and a two-foot landing. The first contestant's feet are placed so the toes are at the end of the first metre stick. That contestant jumps and the landing position of the toes is marked. The approximate jump distance is called out in terms of metres, centimetres, or millimetres. Strive to use all terms since familiarization with prefixes and units is one of the overall objectives.

The first person then steps aside and the toes of the second contestant are placed against the first person's marker. Then this second person jumps. And so it goes until each "volunteer" from that team has participated. The combined total is recorded and the next team is ready to jump. The winner will be the team having jumped the greatest total distance.

If there are several groups and if there is another leader available, one leader can start Team A on one side of the metre sticks while the other leader can follow with Team B on the other side. Then Team C can be done by the first leader, etc.

Total Foot Length. This event uses all team members. Each team is given a few metre sticks and told to find the combined length of their left feet. The contestants line up heel to toe. Only the left foot is used. The shortest length wins. This helps compensate for physical differences and

*Written for project by Douglas K. Brumbaugh, Florida Technological University, Orlando, Florida

injects considerable humor. Decisions involving shoes off or on, standing on toes, etc. must be made prior to the start. If the number of team members is different, some contestants should be designated to go twice. The selection **must** precede the description of the event.

Strongest Person. You will need centimetre grid paper and clay balls of the same mass. Each team selects two "volunteers". Instruct the two participants to remove rings, watches and jewelry. Place the ball of clay on the center of the paper. Each contestant is to hit the ball one time, striving to spread the ball over the largest possible area. Pressing and leaning on the ball are illegal. The clay must be hit with one blow per contestant. The fist may be open or closed. Participants should be cautioned about missing the ball. Some complaints can be eliminated by having new clay for each team but this is not absolutely necessary. In measuring the area, partial squares are combined with completely covered squares to give a total area. The largest area covered wins.

Liquid Volume. You will need water, paper towels, two containers, a small graduated cylinder and eye droppers. Two or more team members are to transfer water from the full container to the empty one using only the eye droppers. This is a time event (a minute or less). Amusement is often directly related to the number of contestants because of the confusion and collisions. When measuring, if the transferred water exceeds the capacity of the graduated cylinder, participants can be given a brief lesson in addition of millilitres.

Solid Volume. You will need centicubes and a cigar or shoe box. The volume of the box is to be estimated by all team members. The one result for each team is written on a piece of paper along with the team name. The closest approximation to the volume (either above or below) wins. All contestants should be kept at least three metres from a table on which the box and centicubes have been placed. Some of the centicubes can be put together to make various lengths to assist with the approximations. You should change the position of the box periodically. Team members may average individual estimates or they may discuss the dimensions and give their volume estimate. This activity provides a good basis for discussion about the merits of individual estimates being averaged and a normal curve as opposed to one estimate agreed upon by a group.

Mass. You will need a kilogram mass piece and a metric bathroom scale. Disguise the kilogram mass by putting it in a bag. Each contestant is isolated and asked to estimate their mass (weight) in terms of the mass in the bag. Once the estimate is recorded, the person steps on the scales and the value is read. The absolute value of the difference between the two results is recorded as the contestant's score. The team having the lowest score is the winner. If team size is not the same, contestants whose masses will be used more than once must be designated before the event is described.

Paper Plate Toss. This can be a total team event. Two team members will throw a paper plate at the same time. The objective is to throw the plate as far as possible since the greatest distance wins. The straight line distance between the take off and landing points is measured. Student participation can be increased by using more pairs from a team and conducting a relay, measuring the final straight line distance.

Straw Toss. This event can easily be done by all team members. Each person throws a drinking straw like a spear (no running or stepping start). A relay can be established by having the first person's landing point be the starting point for the second, etc. until all have participated. The final straight line distance is measured and the team with the greatest measure is the event winner.

Paper Airplanes. This event capitalizes on students' desire to make and fly paper planes. A team can have one member fly the team plane, each member fly the team plane or each member fly their own plane. The straight line distance between the starting point and the landing point is taken to determine the winner.

Punt, Pass, and Kick. You will need a large field and footballs (soccer balls). A line segment long enough to accommodate the desired number of participants should be placed on the field. Individual readings could be recorded and then totaled, thus shortening the needed length for more than one person. A contestant passes (punts or kicks) the ball along that line segment as far as possible. The perpendicular distance the ball lands from the line is subtracted from the length of the toss. The result for each contestant on each part of the event is recorded. The team with the greatest total length is the winner.

Tiddly-Winks. You will need at least two small flat discs or metal flat washers. The player "snaps" one disc by pressing on its edge with the second disc. If this is conducted as a total team relay, the final straight line distance can be measured, giving the winner. Another way is to have contestants attempt to follow a line segment as closely

as possible, subtracting the perpendicular distance from the line segment for each player (like in Punt, Pass, and Kick).

Marble Shoot. In this event, contestants shoot marbles as far as possible. Rules regarding "legal" shots need to be established prior to the event which can be done with individual "volunteers" or a total team relay. Accuracy can be stressed by requiring the shot to be as close to a pre-established line (like in Punt, Pass, and Kick).

Another variation would involve both directional and distance accuracy by having participants shoot at a point. The perpendicular distance off the line segment between the start and finish point would be recorded as would the distance between the stopping point of the marble and the pre-designated target point. The team with the smallest total deviation would win.

A similar event involving rolling a record down a line could be devised.

Linear Estimation. Any length estimation can be used. One suggestion would be to have each individual estimate the length of something to the nearest metre. The team average would then be computed for the team score. If the number of estimators is large enough, the average will be within one metre of the actual length being estimated. This provides an interesting and unusual way of introducing a normal curve and how it functions.

Estimate Liquid Volume. This activity is similar to "Solid Volume" in the original Metric Olympics. The only difference is that it must be explained that one centicube holds one millilitre of water at 4°C. The question then becomes how many millilitres the container holds. Difficulty can be varied by the size and shape of the container.

Another Mass. Frequently toward the end of an Olympics session, participants become reluctant to "volunteer". It is then that this particular event is most enjoyable. Each team submits a "volunteer" who is to go to the front of the room. Once all "volunteers" are there it is announced that they will do nothing but stand there while their combined mass is estimated. Each team will have one estimate recorded and the team closest to the actual value (above or below) wins first place. Estimation can be facilitated by passing a camouflaged kilogram mass around among the estimators.

Square Metre. Since this event requires larger teams, you might need to combine the teams or divide the group into larger groups, have one home room challenge another, boys against the girls, etc. The objective is to see how many people can be fit inside the boundaries of a square metre marked on the floor. Establish the rules before starting. Both feet must be on the floor and inside the square before a person can be counted as being in the square. This will eliminate one student on another's shoulders. Experience quickly shows that the space required for upper bodies exceeds that required for feet. At this point someone will think (don't tell them) to have four people place their feet along the sides of the square, hold hands and lean back, essentially getting their bodies outside the square while having their feet inside. Their weights will counterbalance each others, preventing falls. This idea can be used by two groups of four, making an eight pointed star around the square. Needless to say, this arrangement permits a group to get many more people into the square and win the event.

Scavenger Hunt. This event can use all team members. You will need to have standards and measuring devices that the students can use as a basis for comparison. Give each group a list of measurements and have them find a given number of those measurements in the room. For example, the list could contain 15 items and the group is to find any ten. The fastest group at finding ten items is the first place winner for the event.

The item list would include entries such as: 5 m, 17 cm, 500 g, 1 *l*, etc. As a student finds an example of the measurement, the object name or a description should be written on the sheet. If possible and reasonable, the actual item could be returned for evaluation.

Shopping Assignment. Have students look for metric materials as they shop. You might designate a particular area (food, sports, fashion, sewing) and have the students find specific examples. The student could be required to find examples of particular units or prefixes. This could be done in the stores or via newspapers or catalogs.

APPENDIX D

GUIDELINES FOR EVALUATION OF METRIC PROGRAMS*

The purpose of this set of assessment guidelines and procedures is to assist school divisions in evaluating the measurement component of a school curriculum and to assemble comparative data that should greatly increase their chances of implementing effective metric education programs.

Listed below are five generally accepted recommendations relative to metrication. An assessment procedure and a rationale is presented for each of the recommendations.

I. Use of SI Metric Units

Estimates are that metric changeover will occur within the next eight years. Therefore, the children in school today will live in an SI metric world.

Recommendation #1—The SI (International System) should be taught as the primary measurement system.

Assessment Procedure: To determine the primary measurement system taught by a curriculum unit or program, simply count the number of activities using only SI metric units and the number using customary (English) units. Rank the programs with the highest metric ratio placed first.

$$\frac{\text{\# of metric activities } \square}{\text{\# of total activities } \square} \qquad \frac{\text{\# of English activities } \square}{\text{\# of total activities } \square}$$

II. Use of SI Metric Names and Symbols

The International System of Units (SI) was defined and given official status by the 11th General Congress of Weights and Measures (1960). It is also sanctioned by the U. S. Department of Commerce (National Bureau of Standards, Publication #LC 1056) and numerous educational groups.

Recommendation #2—Metric instructional materials should use only SI metric names and symbols.

Assessment Procedure: Select at least 10% of the pages from the students' materials and follow the four steps below.

Step 1—Count the number of measurement units used on those pages including charts, figures, diagrams, etc.

Step 2—Count the number of measurement units which use SI metric units, prefixes, symbols or approved units used with the metric system.

Step 3—Divide the total figure from Step 2 above by the total from Step 1 and convert to the percent of SI units used in the materials sampled.

$$\frac{\square \leftarrow \text{Step 2}}{\square \leftarrow \text{Step 1}} \times 100 = \boxed{\%}$$

*Adapted with permission from National Council of Teachers of Mathematics, Reston, Virginia.

Step 4—Check the appropriate box on the scale below

☐	☐	☐
99-100%	90-98%	Less than 90%
Consistent w/SI	Partially consistent w/SI	Inconsistent w/SI

III. Emphasis on Metric Measurement and Estimation Activities

To develop measurement and estimation skill requires that students practice using the various metric measurement tools in a variety of meaningful settings.

Recommendation #3—An SI metric curriculum unit or program should give a high degree of emphasis to hands-on metric estimation and measurement activities.

Assessment Procedure: To determine a unit or program's estimation and measurement activity emphasis, either count the total number of activities or take a random sample. Then complete the statements below.

1. The ratio of hands-on measurement activities to the *total* number of activities sampled is—

   number of measurement activities ☐
   ——— /
   total sampled ☐

2. The ratio of hands-on estimation activities to the *total* number of activities sampled is—

   number of estimation activities ☐
   ——— /
   total sampled ☐

3. The ratio of activities that involve *both* estimation and hands-on measurement to the total number of activities sampled is—

   number of estimation-measurement activities ☐
   ——— /
   total sampled ☐

4. Rank order the programs according to their degree of emphasis by placing the unit/programs with the highest ratios first.

IV. Sequence for Instructional Activities

Child development research that describes how children acquire the basic measurement concepts of length, area, volume, and mass shows they progress through ordered stages. It also shows that although the order of the stages is fixed, the progress rate through the stages varies for individuals (Copeland, 1974). Norms and descriptions provided by Copeland (1974) are summarized in Figure 2. (Figure 2 may be used to help decide how and when it is most fruitful to introduce the standard metric units of measurement.)

Recommendation #4—A metric curriculum or program should sequence the content and activities so that they match the learner's stage of development. Instructional activities using a variety of non-standard units are essential before standard measures are used. SI units should be introduced after the children understand the nature of the attributes to be measured.

Assessment Procedure: For each metric program under consideration, complete the following steps for the measure of length.

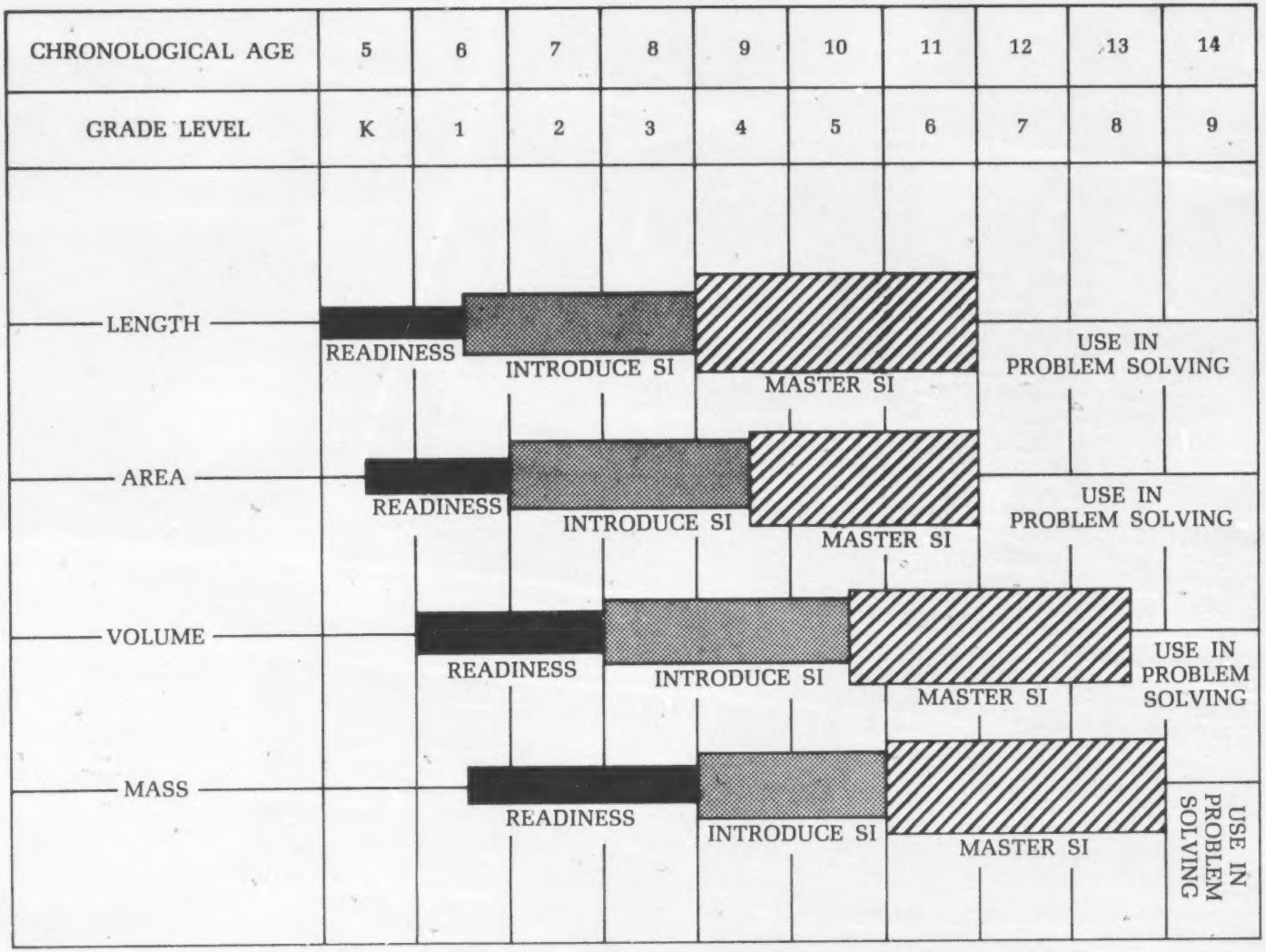

CHRONOLOGICAL AGE
5
6
7
8
9
10
11
12
13
14
GRADE LEVEL
K
1
2
3
4
5
6
7
8
9
LENGTH
READINESS
INTRODUCE SI
MASTER SI
USE IN PROBLEM SOLVING
AREA
READINESS
INTRODUCE SI
MASTER SI
USE IN PROBLEM SOLVING
VOLUME
READINESS
INTRODUCE SI
MASTER SI
USE IN PROBLEM SOLVING
MASS
READINESS
INTRODUCE SI
MASTER SI
USE IN PROBLEM SOLVING

Figure 2

1. Examine teacher's manual, scope and sequence chart, or actual program, and determine the age/grade level where measurement with *standard metric units is first introduced.*
2. Place a check mark on the horizontal line in Figure 2 labeled LENGTH to indicate the age/grade level point where a) non-standard, and b) standard metric units are introduced and, c) where the SI units are to be mastered.
3. Decision Rule—If your check marks fall within the appropriate shaded regions indicated by the chart, the program probably corresponds to the developmental norms now available and is rated "A" (Acceptable). If the marks fall to outside the regions, the program should be rated "U" (Unacceptable).
4. Repeat steps 1-3 above for Area, Volume, and Mass.
5. Repeat steps 1-4 above for each program being investigated.
6. Rank the programs according to the highest number of Acceptable ratings.

V. Interdisciplinary Focus

Experience with change over to the SI metric system in other countries such as England, Canada, and Australia (Chalupsky et al., 1974; Chalupsky et al., 1975) has shown that isolating metric instruction to mathematics or science results in metric measurement being associated only with science and technology. This is an undesirable outcome because use of metrics should be part of everyday life.

Recommendation #5—Teaching the metric system should not be isolated to just science and mathematics activities. Instead, metric education should be integrated into all subject areas where appropriate with each subject area emphasizing the metric units most used in that subject area.

Assessment Procedure: Count the total number of activities. List and then count the subject areas other than science and mathematics where SI metric units are taught. Calculate the percent of total that involves content areas other than science and mathematics. Mark the appropriate boxes on the scales below.

number of non-science-math activities ☐

total number of activities ☐

Number of non-math-science areas

☐ 0- ☐ 1-2 ☐ 3-5

number of non-math/science activities

total number of activities

percent of total

☐ 25% Low ☐ 26-50% ☐ 51-75% ☐ 75% High

APPENDIX E

TEACHER'S SELF-INVENTORY*

Teachers should be provided with inservice training and teaching guides that focus on the metric knowledge, measurement and estimation skills they will be required to teach. Hence, in-service programs should be planned based upon needs assessment data that includes a teacher self-inventory.

Evaluation Procedure:

Distribute a self-inventory to teachers at all levels before inservice is planned. Have the teachers return the inventory to the person or metric selection committee responsible for planning the inservice program. Compile the data from the inventory by grade or curriculum levels. The data from the self-inventories should be summarized.

*Adapted with permission from project IMPACT, Pennsylvania State University, University Park, Pennsylvania.

Teacher's Self-Inventory*

Subject Area _____ Grade Level _____

Items	Rating				
	Excellent	Above Average	Average	Below Average	Poor
I would rate my skill in:					
1) Estimating with metric units as	1	2	3	4	5
2) Measuring with metric instruments as	1	2	3	4	5
3) Developing student activities for my classroom as	1	2	3	4	5
I would rate my knowledge of:					
4) The content and structure of the SI metric system as	1	2	3	4	5
5) Sources of curriculum materials as ..	1	2	3	4	5
6) Stages through which children's measurement skill and ability progress as	1	2	3	4	5

*Adapted with permission from project IMPACT, Pennsylvania State University, University Park, Pennsylvania.

This summary should then be compared with the requirements of the metric curriculum units or programs to be used by the teachers at each level.

To assist the selection committee in making the comparison just suggested, the following rating scale should be completed and the results compared item by item with the summary of the teachers' self-inventories. Inservice programs should be planned around those areas in the curriculum where high emphasis is placed and where the teacher's inventory shows a rating of average and below.

Unit/Program Inventory by Grade Level

Grade or Level ____

Program/Unit	Components	Amount of Emphasis		
		High	Medium	Low
1	Estimation Activities	1	2	3
2	Measurement Activities	1	2	3
3	Teacher-Made Activities	1	2	3
4	Content and Structure of SI System	1	2	3
5	Use of Multi-Media Resources	1	2	3
6	Use of Stages of Cognitive Development to Sequence Instructional Activities	1	2	3

A profile should be developed to show the results of the comparison.

APPENDIX F

METRIC MEASUREMENT ATTITUDE SCALE*

This is to find out how you feel about switching to the metric measurement system. You are to read each statement carefully and decide how you feel about the changeover. Then indicate your feeling by shading the correct space on your answer sheet. You should shade:

A—if you strongly agree with the statement

B—if you agree with the statement

C—if your feeling is neutral about the statement

D—if you disagree with the statement

E—if you strongly disagree with the statement

1. The school system should tool up immediately to teach metric measurement.
2. I ignore the metric part of dual labels when I am shopping.
3. The metric system of measurement is anti-American.
4. I will never understand the metric system.
5. Metric measurement is easier for me to understand than English measurement system.
6. Metric measurement confuses me.
7. I believe metric measurement is easier to use than the English system.
8. I convert from metric to English measurement instead of using metric.
9. I anticipate converting to metric measurement.
10. Metric measurement is exciting.
11. I believe the economic future of our country rests on our conversion to the metric system.
12. I look forward to the ease metric measurement will bring.
13. Thinking metric is no problem for me.
14. The metric system of measurement will destroy an important part of the American culture.

*Adapted with permission from Project IMPACT, Pennsylvania State University, University Park, Pennsylvania.

15. When we switch to the metric system, I will continue to use English units of measurement.
16. I am apprehensive about anything associated with metric measurement.
17. I have already begun using some metric measurement.
18. I believe the metric system is easy to learn.
19. I expect learning metric measurement to be enjoyable.
20. I am reluctant to change to the metric system.
21. Only scientists and engineers need to know the metric system.
22. Estimation is easier for me when I use metric units of measurement.

APPENDIX G

CRITERIA FOR SELECTING METRIC MATERIALS AND EQUIPMENT

A change in measuring units necessitates a change in materials and equipment. Many of the devices needed to teach measurement can be made by the teacher or by the students in the classroom, thus providing an excellent teaching activity. There is a need, nevertheless, for schools to purchase some metric materials and metric measuring devices.

Commercial publishing companies being aware of federal metric legislation anticipated the market for new metric materials and equipment. As a result a plethora of materials, many of inferior quality, were produced. Hence, when choosing metric materials consideration should be given to quality and appropriateness. Listed below are some suggested guidelines for selecting audiovisual and printed materials.

1. Select only those materials that use proper SI notation and symbols.
2. Select materials that emphasize conversion within the metric system and not conversion between systems of measurement.
3. Select materials that make provision for an activity-oriented approach to learning rather than a paper-and-pencil approach.
4. Select materials that give consideration to sequencing of content and measurement activities in terms of stages of child development.
5. Select textbooks that emphasize SI metrics in all sections dealing with measurement.
6. Select those audiovisual materials that are designed to create an awareness of or an introduction to the metric system. Consideration should also be given to the grade levels for which the materials are appropriate.

When purchasing measurement devices for use in the teaching of SI metrics, consideration should be given to precision, appropriateness of construction, and usability. Listed below are some suggested specifications for certain devices.

1. Metal mass pieces should be accurate to within 2 g of their stated mass.
2. A bathroom scale should be accurate to within 1.5 per cent across the entire dial.
3. A pan balance should be sensitive to 0.2 g with a zero adjust device.
4. A surveyor's tape should be made of fiberglass or metal and calibrated in centimetres and metres.
5. A trundle wheel should be made of wood or unbreakable plastic with a handle supporting the disc on both sides, calibrated in centimetres and equivalent decimal fractions of a metre.
6. A spring scale should be made of metal with a capacity of at least 6 kg and 100 g graduations.
7. Graduated beakers should be made of unbreakable plastic with hot-stamped graduations and have two pouring spouts or be labeled in such a way that they can be conveniently read by both left-handed and right-handed people.
8. A cubic decimetre should be made of unbreakable plastic with hot-stamped calibrations.
9. An indoor thermometer should be immersible and metal-backed with a range of at least $-10°C$ to $+100°C$.
10. An outdoor thermometer should have an indicated range of at least $-30°C$ to $+50°C$.
11. A tape measure (150 cm) should be graduated in millimetres and centimetres with a vertical readout on one side and a horizontal readout on the other side.
12. Rulers and metre sticks should be designed with deadlength and be calibrated in millimetres, centimetres, or decimetres, according to the grade level for which they will be used.

APPENDIX H

SAMPLE TEST ITEMS

A quality testing program is a must for preservice education as well as a means of evaluating the effectiveness of inservice programs and school instructional programs.

What follows are examples of items that may be used in a metric measurement test. The items fall in three broad categories; items to test metric knowledge; items dealing with estimation skills; and items dealing with measurement skills. This is **not** intended to be a complete test.

Metric Knowledge

1. One centimetre is equal to:
   A. .1 metre
   B. .01 metre
   C. .001 metres
   D. 10. metres
   E. 100. metres

1. One kilogram is equal to:
   A. .01 gram
   B. .001 gram
   C. 10. grams
   D. 100. grams
   E. 1000. grams

3. One litre of water has a mass equal to approximately:
   A. 1 kilogram
   B. 1 milligram
   C. 1 gram
   D. 1 centigram
   E. 1 dekagram

4. The temperature at which water freezes on the Celsius scale is:
   A. 37.5°C
   B. 0°C
   C. 32°C
   D. 100°C
   E. 212°C

5. The base unit for mass (weight) in the metric system is the:
   A. litre
   B. gram
   C. kilogram
   D. milligram
   E. centimetre

6. To convert kilometres to metres multiply by:
   A. 100.
   B. 1000.
   C. .1
   D. .01
   E. .001

Metric Estimation Skills

The person administering the test should show an object, indicate a location or ask the student to visualize an object from memory. Criteria for determining appropriateness of estimates should be established prior to testing.

7. Estimate the height of the file cabinet to the nearest centimetre.
8. Estimate the length of the corridor in metres.
9. Estimate the area of this book cover in square centimetres.
10. Estimate the volume of a juice can in litres.

Metric Measurement Skills

Your ability to correctly measure using simple equipment calibrated in the (SI) metric system will be tested in the following items. The individual administering the test must provide the necessary measuring tools and objects to be measured. The degree of accuracy desired should be established prior to testing.

11. Using a metre stick or metric tape, measure the length of the room.
12. Using a graduated cylinder, measure the volume of water which could be contained in the soft drink can.
13. Using a metric pan balance, measure the mass of the book.